PHYSICAL GEOGRAPHY.

VOLUME II.

PHYSICAL GEOGRAPHY.

BY

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CHAPTER XX.

Lakes — Northern System of the Great Continent — Mountain System of the same — American Lakes.

THE hollows formed on the surface of the earth by the ground sinking or rising, earthquakes, streams of lava, craters of extinct volcanos, the intersection of strata, and those that occur along the edges of the different formations, are generally filled with water, and constitute systems of lakes, some salt and some fresh. Many of the former may be remnants of an ancient ocean left in the depressions of its bed during its retreat as the continents arose.

Almost all lakes are fed by springs in their beds, and they are occasionally the sources of the largest rivers. Some have neither tributaries nor outlets; the greater number have both. The quantity of water in lakes varies with the seasons everywhere, especially from the melting snow on mountain-chains and in high latitudes, and from periodical rains, between the tropics. Small lakes occur in mountain-passes, formed by water which runs into them from the commanding peaks; they are fre-

quently, as in the Alps, very transparent, of a bright green or azure hue. Large lakes are common on table-lands, and in the valleys of mountainous countries, but the largest are on extensive plains. The basin of a lake comprehends all the land drained by it; consequently it is bounded by an imaginary line passing through the sources of all the waters that fall into it.

There are more lakes in high than in low latitudes, because evaporation is much greater in low latitudes than in high, and in this respect there is a great analogy between the northern plains of the two principal continents. Sheets of water of great beauty occur in the mountain valleys of the British islands, of Norway, and Sweden, countries similar in geological structure; and besides these there are two regions in the old world in which lakes particularly abound. One begins on the low coast of Holland, goes round the southern and eastern sides of the Baltic, often passing close to its shores, along the Gulf of Bothnia, and through the Siberian plains to Behring's Straits. The lakes which cover so much of Finland and the great lakes of Ladoga and Onega lie in a parallel direction; they occupy transverse rents which had taken place across the palæozoic strata, while rising in a direction from S.W. to N.E., between the Gulf of Finland and the White Sea; that elevation was, perhaps, the cause of the cavities now occupied by these two seas. Ladoga is the largest lake in this zone, having a surface of nearly 1000 square miles. It receives tributary

streams, and sends off its superfluous water by rivers, and Onega does the same; but the multitude of small steppe lakes among the Ural mountains and in the basin of the river Obi neither receive nor emit rivers, being for the most part mere ponds, though of great size, some of fresh and some of salt water, lying close together—a circumstance which has not been accounted for: those on the low Siberian plains have the same character.

The second system of lakes in the old continent follows the zone of the mountain mass, and comprehends those of the Pyrenees, Alps, Apennines, Asia Minor, the Caspian, the Lake Aral, together with those on the table-land and in the mountains of central Asia.

In the Pyrenees lakes are most frequent on the French side; many are at such altitudes as to be perpetually frozen; one on Mont Perdu, 8393 feet above the sea, has the appearance of an ancient volcanic crater. There is scarcely a valley in the Alpine range and its offsets that has not a sheet of water, no doubt owing to the cavities formed during the elevation of the ridges, and in some instances to subsidence of the soil: Lake Trüb, 7200 feet above the level of the sea, is the most elevated. There are more lakes on the north than on the south side of the Alps—the German valleys are full of them. In Bohemia, Gallicia, and Moravia there are no less than 30,000 sheets of water, besides great numbers throughout the Austrian empire.

Of the principal lakes on the northern side of the

Alps, the Lake of Geneva, or Lake Leman, is the most beautiful from its situation, the pure azure of the waters, and the sublime mountains that surround it. Its surface, of about 240 square miles, is 1150 feet above the sea, and near Meillerie it is 1012 deep. The Lake of Lucerne is 1400 feet above the sea, and the lakes of Brienz 1900 feet. The Italian Lakes are at a lower level; the Lago Maggiore has only 678 feet of absolute altitude; they are larger than most of those on the north of the Alps, and, with the advantage of an Italian climate, sky, and vegetation, they surpass the others in beauty, though the mountains that surround them are less lofty.

These great lakes are fed by rivers rising in the glaciers of the higher Alps, and many large rivers issue from them. In this respect they differ from most of the lakes in Lower Italy, some of which are craters of ancient volcanos, or perhaps ancient craters of elevation, where the earth had been swelled up by subterranean vapour without bursting, and had sunk down again into a hollow when the internal pressure was removed.

In Syria, the Lake of Tiberias and the Dead Sea, sacred memorials to the Christian world, are situate in the deepest cavity on the earth. The surface of the Lake Tiberias is 329 feet below the level of the Mediterranean, surrounded by verdant plains bearing aromatic shrubs; while the heavy bitter waters of the Dead Sea, 1312 feet below the level of the Mediterranean, is a scene of indescribable desolation and solitude, encompassed by desert sands, and

bleak, stony, salt hills. Thus there is a difference of level of 983 feet in little more than 60 miles, which makes the course of the river Jordan very rapid. The water of the Dead Sea is so acrid from the large proportion of saline matter it contains that it irritates the skin: it is more buoyant, and has a greater proportion of salt, than any that is known except the small lake of Eltonsk east of the Volga.

Though extensive sheets of water exist in many parts of Asia Minor, especially in Bithynia, yet the characteristic feature of the country, and of all the table-land of western Asia and the adjacent steppes, is the number and magnitude of the saline lakes. A region of salt lakes and marshes extends at least 200 miles along the northern foot of the Taurus range, on a very elevated part of the table-land of Anatolia. There are also many detached lakes, some exceedingly saline. Fish cannot live in the Lake of Toozla; it is shallow, and subject to excessive evaporation. Neither can any animal exist in the Lake of Shahee or Urmiah, on the confines of Persia and Armenia, 300 miles in circumference: its water is perfectly clear, and contains a fourth part of its weight of saline matter. These lakes are fed by springs, rain, and melted snow, and, having no emissaries, the surplus water is carried off by evaporation.

It is possible that the volcanic soil of the table-land may be the cause of this exuberance of salt water. Lake Van, a sheet of salt water 240 miles in circumference, is separated from the equally salt lake Urmiah only by a low range of hills: and there

are many pieces of fresh water in that neighbourhood, possibly in similar hollows.

Persia is singularly destitute of water; the Lake of Zurrah, on the frontiers of Afghanistan, having an area of 18 square miles, is the only piece of water on the western part of the table-land of Iran.

It is evident from the saline nature of the soil, and the shells it contains, that the plains round the Caspian, the Lake Aral, and the steppes, even to the Ural Mountains, had once formed part of the Black Sea; 57,000 square miles of that country are depressed below the level of the ocean—a depression which extends northwards beyond the town of Saratov, 300 miles distant from the Caspian. The surface of the Caspian itself, which is 83 feet 7 inches below the level of the ocean, is its lowest part, and has an area of 18,000 square miles, nearly equal to the area of Spain. In Europe alone it drains an extent of 850,000 square miles, receiving the Volga, the Ural, and other great rivers on the north. It has no tide, and its navigation is dangerous from heavy gales, especially from the south-east, which drive the water miles over the land; a vessel was stranded 46 miles inland from the shore. It is 600 feet deep to the south, but is shallower to the east, where it is bounded by impassable swamps many miles broad. The Lake of Eltonsk, on the steppe east of the Volga, has an area of 130 square miles, and furnishes two-thirds of the salt consumed in Russia. Its water yields 29·13 per cent. of saline

matter, and from this circumstance is more buoyant than any that is known.[1]

The Lake of Aral, which is shallow, is higher than the Caspian, and has an area of 3372 square miles; it has its name from the number of small islands at its southern end, Aral signifying "island" in the Tartar language. Neither the Caspian nor the Lake of Aral have any outlets, though they receive large rivers; they are brackish, and, in common with all the lakes in Persia, they are decreasing in extent, and becoming more salt, the quantity of water supplied by tributaries being less than that lost by evaporation. Most of the rivers that are tributary to the Lake of Aral are diminished by canals, that carry off water for irrigation: for that reason a very diminished portion of the waters of the Oxus reaches the lake. Besides, the Russian rivers yield less water than formerly from the progress of cultivation. The small mountain-lake Sir-i-Kol, in the high table-land of Pamer, from whence the Oxus flows, is 15,600 feet above the sea; consequently there is a difference of level between it and the Dead Sea of nearly 17,000 feet.

The small number of lakes in the Himalaya is one of the peculiarities of these mountains. The Lake of Ular, in the valley of Cashmere, is the only one of any magnitude; it is but 40 miles in circumference, and seems to be the residue of one that had filled the

[1] The water of the Dead Sea contains 26·24 per cent. of saline ingredients, one of which is sulphate of magnesia. The water of Lake Eltonsk contains chloride of calcium.

whole valley at some early period. There are many great lakes, both fresh and salt, on the table-land; the annular form of Lake Palte, at the northern base of the Himalaya, as represented on maps, is unexampled; the sacred lakes of Manasarowar, in Great Tibet, and of Rakas Tal, occupy a space of about 400 square miles, in the centre of the Himalaya, between the gigantic peaks of Gurla on the south and of Kailas on the north; it is from the westernmost of these lakes (which communicate with each other), the Cho Lagan of the Tibetians, that the Sutlej rises, at an elevation of 15,200 feet above the level of the sea. These remarkable lakes mark the point from around which all the great rivers rising in the Himalaya have their origin. Tibet is full of lakes, many of which produce borax, found nowhere else but in Tuscany and in the Lipari Islands. As most of the great lakes on the table-land are in the Chinese territories, strangers have not had access to them; the Koko-nor and Lake Lop seem to be very large; the latter is said to have a surface of 2187 square miles, and there are others not inferior to it in the north. The lakes in the Altaï are beautiful, larger and more numerous than in any other mountain-chain. They are at different elevations on the terraces by which the table-land descends to the flats of Siberia, and are, owing to geological phenomena, essentially different from those which have produced the Caspian and other steppe lakes. They seem to have been hollows formed where the axes of the different branches of the chain cross, and

are most numerous and deepest in the eastern Altaï. Baikal, the largest mountain lake, supposed to owe its origin to the sinking of the ground during an earthquake, has an area of 14,800 square miles, nearly equal to the half of Scotland. It lies buried in the form of a crescent, amid lofty granite mountains, which constitute the edge of the table-land to the south, ending in the desert of the Great Gobi, and in the north-west they gird the shore so closely that they dip into the water in many places; 160 rivers and streams fall into this salt lake, which drains a country probably twice the size of Britain. The river Angara, which runs deep and strong through a crevice at its eastern end, is its principal outlet, and is supposed to carry off but a small proportion of its water. Its surface is 1793 feet above the sea-level, and the climate is as severe as it is in Europe 10° farther north; yet the lake does not freeze till the middle of December, possibly from its depth, being unfathomable with a line of 600 feet.

Two hundred and eighty years before the Christian era, the large fresh-water lake of Oitz, in Japan, was formed in one night, by a prodigious sinking of the ground, at the same time that one of the highest and most active volcanos in that country rose from the depths of the earth.

Very extensive lakes occur in Africa; there appears to be a great number on the low lands on the east coast of Africa, in which many of the rivers from the edge of the table-land terminate. Among others

there is the salt lake Assal, 25 miles west of Tadjurra, in the country through which the Hawash flows, which has a depression of more than 700 feet below the level of the ocean, by Dr. Beke's estimation, who first observed that curious circumstance; but by the actual measurement of Lieutenant Cristopher, it is 570 feet. Notwithstanding the arid soil of the southern table-land, it contains the fresh-water lake of N'yassi or Zambeze, one of the largest, being some hundred miles long; and, though narrow in proportion, it cannot be crossed in a boat of the country in less than three days, resting at night on an island, of which there are many. It lies between 300 and 400 miles west from the Mozambique Channel, and begins 200 miles north of the town of Tete, which is situate on the river Zambeze, from whence it extends from south-east to north-west, possibly to within a degree or two of the equator. It receives the drainage of the country to the south-east: but no river is known to flow out of it, unless it be the Bahr-el-Abiad or White Nile, which probably rises in this lake. No one knows what there may be in the unexplored regions of the Ethiopian desert; but Abyssinia has the large and beautiful lake of Dembia, situate in a spacious plain—the granary of the country—so high above the sea that spring is perpetual, though within the tropics. There are many other lakes in this great projecting promontory, so full of rivers, mountains, and forests; but the lowlands of Soudan and the country lying along the base of the northern declivity of the table-

land is the region of African lakes, of which the Tchad, almost the size of an inland sea, is in the very centre of the continent. Its extent, and the size of its basin, are unknown; it receives many affluents from the high lands called the Mountains of the Moon, certainly all those that flow from them east of Bornou, and it is itself drained by the Tchadda, a principal tributary of the Niger. Other lakes of less magnitude are known to exist in these regions, and there are probably many more that are unknown. Salt-water lakes are numerous on the northern boundaries of the great lowland deserts, and many fine sheets of fresh water are found in the valleys and flat terraces of the Great and Little Atlas.

Fresh-water lakes are characteristic of the higher latitudes of both continents, but those in the old continent sink into insignificance in comparison with the number and extent of those in the new. Indeed a very large portion of North America is covered with fresh water; the five principal lakes—Superior, Huron, Michigan, Erie, and Ontario—with some of their dependants, probably cover an area of 94,000 square miles; that of Lake Superior alone, 32,000, which is only 1800 square miles less than the whole of England. The American lakes contain more than half the amount of fresh water on the globe. The altitude of these lakes shows the slope of the continent; the absolute elevation of Lake Superior is 672 feet; Lake Huron is 30 feet lower; Lake Erie 32 feet lower than the Huron; and Lake Ontario is 331 feet below the level of Erie. The river Niagara,

which unites the two last lakes, is 33½ miles long, and in that distance it descends 66 feet; it falls in rapids through 55 feet of that height in the last half-mile, but the upper part of its course is navigable. The height of the cascade of Niagara is 162 feet on the American side of the central island, and 1125 feet wide. On the Canadian side the fall is 149 feet high, and 2100 feet wide — the most magnificent sheet of falling-water known, though many are higher. The river St. Lawrence, which drains the whole, slopes 234 feet between the bottom of the cascade and the sea. The bed of Lake Superior is 300 feet, and that of Ontario 268 feet, below the surface of the Atlantic, affording another instance of deep indentation in the solid matter of the globe. Some lakes are decreasing in magnitude, though the contrary seems to be the case in America; between the years 1825 and 1838, Ontario rose nearly seven feet; and, according to the American engineers, Lake Erie had gained several feet in the same time. Lake Huron is said to be the focus of peculiar electrical phenomena, as thunder is constantly heard in one of its bays. The lakes north of this group are innumerable; the whole country, to the Arctic Ocean, is covered with sheets of water which emit rivers and streams. Lake Winnipeg, Rein-deer Lake, Slave Lake, and some others, may be regarded as the chief members of separate groups or basins, each embracing a wide extent of country almost unknown. There are also many lakes on each side of the Rocky Mountains; and in Mexico there are six

or seven lakes of considerable size, though not to be compared with those in North America.

There are many sheets of water in Central America, though only one is of any magnitude, and the Lake of Nicaragua, in the province of that name, about 100 miles from the sea, and which communicates with the Gulf of Mexico by the River of San Juan.

In Central America the Andes are interrupted by plains and mere hills on the Isthmus of Tehuantepec and of Nicaragua, on each side of which there is a series of lakes and rivers, which, aided by canals, might form a water communication between the Atlantic and Pacific oceans. In the former, the line proposed would connect the river Guasacalco, on the Gulf of Mexico, with the Bay of Tehuantepec in the Pacific. In the Isthmus of Nicaragua, the Gulf of San Juan would be connected by the river of that name, and the chain of Lakes of Nicaragua and Leon, with the Bay of Realejo or the Gulf of Fonseca, with the Gulf of Costa Rica. Here the watershed is only 615 feet above the sea, and of easy excavation, and the lake, situate in an extensive plain, is deep enough for vessels of considerable size.

A range of lakes goes along the eastern base of the Andes, but the greater part of them are mere lagoons or marshes, some very large, which inundate the country to a great extent in the time of the tropical rains. There appears to be a deep hollow in the surface of the earth at the part where Bolivia,

Brazil, and Paraguay meet, in which lies the Lake Xarayos, extending on each side of the river Paraguay, but, like many South American lakes, it is not permanent, being alternately inundated and dry, or a marsh. Its inundations cover 36,000 square miles. Salt and fresh water lakes are numerous on the plains of La Plata, and near the Andes in Patagonia, resembling in this respect those in high northern latitudes, though on a smaller scale.

In the elevated mountain-valleys and table-lands of the Andes there are many small lakes of the purest blue and green colours, intensely cold, some being near the line of perpetual congelation. They are generally of considerable depth. The lake of Titicaca, however, in the Bolivian Andes, has an area of 2225 square miles, of 60 to a degree, and is more than 120 fathoms deep in many places, surrounded by splendid scenery. Though 12,846 feet above the level of the Pacific, and consequently higher than the Peak of Teneriffe, its shores are cultivated, producing corn, barley, and potatoes; and peopled by a large aboriginal population, inhabiting towns and villages. Numerous vestiges of Peruvian civilization are everywhere to be met with; and in the island from which it derives its name, and where tradition places the origin of the last Inca dynasty, numerous specimens of Peruvian architecture still exist.

The limpid transparency of the water in lakes, especially in mountainous countries, is remarkable; minute objects are visible at the bottom through

many fathoms of water. The vivid green tints so often observed in Alpine lakes may be produced by vegetable dyes dissolved in the water, though chemical analysis has not detected them.

Lakes, being the sources of some of the largest rivers, are of great importance for inland navigation as well as for irrigation; while, by their constant evaporation, they maintain the supply of humidity in the atmosphere so essential to vegetation, besides the embellishment a country derives from them.

CHAPTER XXI.

Temperature of the Earth — Temperature of the Air — Radiation — Foci of Maximum Cold — Thermal Equator — Its Temperature, mean and absolute — Isothermal Lines — Continental and Insular Climates — Extreme Climates — Stability of Climate — Decrease of Heat in Altitude — Line of Perpetual Snow — Density of the Atmosphere — The Barometer — Measurement of Heights — Variations in Density and their Causes — Horary Variations — Independent Effect of the dry and aqueous Atmospheres — Mean Height of Barometer in different Latitudes — Depression in the Antarctic Ocean and in Eastern Siberia — Barometric Storms — Polar and Equatorial Currents of Air — Trade Winds — Monsoons — Land and Sea Breezes — Gyration of the Winds in the Extra-Tropical Zones — Winds in Middle European Latitudes — Hurricanes — The Laws of their Motion — Their Effect on the Barometer — How to steer clear of them — The Storm-Wave — Storm-Currents — Arched Squalls — Tornadoes — Whirlwinds — Water Spouts.

The atmosphere completely envelops the earth to the height of about 50 miles; it bulges at the equator, and is flattened at the poles, in consequence of the diurnal rotation. It is a mixture of water in an invisible state and of air; but the air is not homogeneous; 100 parts of it consist of 79 parts of nitrogen or azotic gas, and 21 of oxygen, the source of combustion and animal heat. Besides these, there is a little ammoniacal vapour, and a small quantity of carbonic acid gas, which is sufficient to supply all the vegetation on the earth with wood and leaves.

No doubt exhalations of various kinds ascend into the air, such as those which produce miasmata, but they are in quantities too minute to be detected by chemical analysis, so that the atmosphere is found to be of the same composition at all heights above the sea hitherto attained.[1]

The temperature of the earth's surface, and the phenomena of the atmosphere, depend upon the revolution and rotation of the earth, which successively expose all the parts of the earth, and the air which surrounds it, to a perpetual variation of the gravitating forces of the two great luminaries, and to annual and diurnal vicissitudes of solar heat. Atmospheric phenomena are consequently periodical and connected with one another, and their harmony, and the regularity of the laws which govern them, become the more evident in proportion as the mean values of their vicissitudes are determined from simultaneous observations made over widely extended tracts of the globe. The fickleness of the wind and weather is proverbial, but, as the same quantity of heat is annually received from the sun, and annually radiated into space, it follows that all climates on the earth are stable, and that their changes, like the perturbations of the planets, are

[1] Professor Schoenbein of Basle attributes the peculiar smell, when bodies are struck by lightning, to a principle existing in the atmosphere, which he calls ozone, liberated by the decomposing action of electricity, and possessing the same electrical characters as bromine, chlorine, and iodine. He ascribes the luminous appearance of the ocean to the action of that principle on the animal matter it contains.

limited, and accomplished in fixed cycles, whose periods are still in many instances unknown. It is possible, however, that the earth and air may be affected by secular variations of temperature during the progress of the solar system through space, or from periodical changes in the sun's light and heat, similar to those which take place in many of the fixed stars. The secular variation in the moon's mean distance will no doubt alter the amount of her attractive force, though probably by a quantity inappreciable in the aërial tides; at all events variations arising from such circumstances could only become perceptible after many ages.

From experiments made by M. Peltier it appears that, if the absolute quantity of heat annually received by the earth were equally dispersed over its surface, it would, in the course of a year, melt a stratum of ice 46 feet deep covering the whole globe. It is evident that, if so great a quantity of heat had been continually accumulated in the earth, instead of being radiated into space, it would have been transmitted through the surface to the poles, where it would have melted the ice, and the torrid zone, if not the whole globe, would by this time have been uninhabitable. In fact, every surface absorbs and radiates heat at the same time, and the power of radiation is always equal to the power of absorption, for, under the same circumstances, bodies which become soon warm also cool rapidly, and the earth, as a whole, is under the same law as the bodies at its surface.

Although part of the heat received from the sun in summer is radiated back again, by far the greater part sinks into the earth's surface, and tempers the severity of the winter's cold while passing through the atmosphere into the etherial regions.

The power of the solar rays depends on the manner in which they fall, as may be seen from the difference of climates. The earth is about 3,000,000 of miles nearer to the sun in winter than in summer, but the rays strike the northern hemisphere more obliquely in winter than in the other half of the year.

Diurnal variations of heat are perceptible only to a small distance below the surface of the ground, because the earth is a bad conductor: the annual influence of the sun penetrates much farther. At the equator, where the heat is greatest, it descends deeper than elsewhere with a diminishing intensity, but there, and everywhere throughout the globe, there is a stratum, at a depth varying from 40 to 100 feet below the surface of the ground, where the temperature never varies, and is nearly the same with the mean temperature of the country over it. This zone, unaffected by the sun's heat from above, or by the internal heat from below, serves as an origin whence the effects of solar heat are estimated on one hand, and the internal temperature of the globe on the other. Below it the heat of the earth increases, as already mentioned, at the rate of one degree of Fahrenheit's thermometer for every 50 or 60 feet of perpendicular depth; were it to continue increasing

at that rate, every substance would be in a state of fusion at the depth of 21 miles; hitherto, however, the experiments in mines and Artesian wells, whence the earth's temperature below the constant stratum is ascertained, have not been extended below 1700 feet.

M. de Beaumont has estimated by the theory of Fourier, from the observations of M. Arago, that the quantity of central heat which reaches the surface of the earth is capable, in the course of a year, of melting a shell of ice covering the globe a quarter of an inch thick.[1]

The superficial temperature of the earth is great at the equator, it decreases gradually towards the poles, and is an exact mean between the two at the 45th parallel of latitude; but a multitude of causes disturb this law even between the tropics. It is affected chiefly by the unequal distribution of land and water, by the height above the sea, by the nature of the soil, and by vegetation, so that a line drawn on a map through all the places where the mean temperature of the earth is the same would be very far from coinciding with the parallels of latitude, but would approximate more to them near the equator. Between the tropics the temperature of the earth's surface is greater in the interior of continents than on the sea-coasts and islands, and in the interior of Africa it is greater than in any other part of the globe.

Temperature depends upon the property all bodies

[1] Annales des Sciences Géologiques, par M. Rivière, 1842.

possess, more or less, of perpetually absorbing and emitting or radiating heat. When the interchange is equal, the temperature of a substance remains the same; but when the radiation exceeds the absorption, it becomes colder, and *vice versâ*. The temperature of the air is certainly raised by the passage of the solar heat through it, because it absorbs one-third of it before reaching the earth, but it is chiefly warmed by heat transmitted and radiated from the earth. The radiation is abundant when the sky is clear and blue, but clouds intercept it; so that a thermometer rises in cloudy weather, and sinks when the air becomes clear and calm; even a slight mist diminishes radiation from the earth, because it returns as much heat as it receives. The temperature of the air is subject to such irregularities from these circumstances, and from the difference in the radiating powers of the bodies at the surface of the globe, that it is necessary to find, by experiment, the mean or average warmth of the day, month, and year, at a great variety of places, in order to have a standard by which the temperature in different parallels of latitude may be compared.

The mean diurnal temperature of the air, at any place, is equal to half the sum of the greatest and least heights of the thermometer during 24 hours, and, as the height of the thermometer is twice in the course of that time equal to the mean temperature of the place of observation, it might seem easy to obtain its value; yet that is not the case, for a small error in observation produces a very great error in

such minute quantities, so that accuracy can only be attained from the average of a great number of observations, by which the errors, sometimes in excess and sometimes in defect, neutralize or balance each other. The mean value of quantities is a powerful aid to the imperfections of our nature in arriving at truth in physical inquiries, and in none more than in atmospheric phenomena: almost all the certain knowledge man has acquired with regard to the density and temperature of the air, winds, rain, &c., has been acquired by that method.

The mean temperature of any one month at the same place differs from one year to another, but the mean temperature of the whole year remains nearly the same, especially when the average of 10 or 15 years is taken; for although the temperature in any one place may be subject to very great variations, yet it never deviates more than a few degrees from its mean state.[1]

The motion of the sun in the ecliptic occasions perpetual variations in the length of the day, and in the direction of his rays with regard to the earth; yet, as the cause is periodic, the mean annual temperature from the sun's motion alone must be con-

[1] The mean of any number of unequal quantities is equal to their sum divided by their number: thus the mean temperature of the air at any place during a year is equal to the sum of the mean temperature of each month divided by 12. This method, however, will only give an approximate value; therefore, to ascertain the mean annual temperature at any place accurately, the mean of a number of years must be taken.

stant in each parallel of latitude. For it is evident that the accumulation of heat in the long days in summer, which is but little diminished by radiation during the short nights, is balanced by the small quantity of heat received during the short days of winter and its radiation in the long frosty and clear nights. Were the globe everywhere on a level with the surface of the sea, and of uniform substance, so as to absorb and radiate heat equally, the mean heat of the sun would be regularly distributed over its surface in zones of equal annual temperature parallel to the equator, and would decrease regularly to each pole. The distribution of heat however in the same parallel is very irregular in all latitudes, except between the tropics, from the inequalities in the level and nature of the surface of the earth, so that lines drawn on a map through all places having the same mean annual temperature are nearly parallel to the equator only between the tropics; in all other latitudes they deviate greatly from it, and from one another.[1] Radiation is the principal cause of temperature; hence the heat of the air is most powerfully modified by the ocean, which occupies three times as much of the surface of the globe as the land, and is more uniform in its surface, and also in its radiating power. On the land the difference in the radiating force of the mountains and table-lands from that of the plains—of deserts from grounds

[1] Lines drawn on a map or globe through all places where the mean annual temperature is the same are isothermal lines.

covered with rich vegetation—of wet land from dry, are the most general causes of variation; the local causes of irregularity are beyond enumeration.

There are two points in the northern hemisphere, both in the 80th parallel of latitude, where the cold is more intense than in any other part of the globe with which we are acquainted. One north of Canada in 100° W. long. has a temperature of − 3°·5 of Fahrenheit; while at the Siberian point, in 95° E. long., the temperature of the air is + 1°; consequently it is four and a half degrees warmer than that north of Canada—a difference that has an influence even to the equator, where the mean temperature of the air is different in different longitudes.

The line of the maximum temperature of the atmosphere, or the atmospheric thermal equator, which cuts the terrestrial equator in the meridians of Otaheite and Singapore, passes through the Pacific in its southern course, and through the Atlantic in its northern, has a mean temperature of 83°·84 of Fahrenheit. But by the comparison of many observations the mean equatorial temperature of the air is 82°·94 in Asia, 85°·10 in Africa, and 80°·96 in America: thus it appears that tropical Africa is the hottest region on earth. Moreover, the atmosphere in the tropical zone of the Pacific, when free from currents, is two degrees and a quarter warmer than the corresponding zone in the Atlantic, which is 82°·40.

On account of the great extent of ocean, the isothermal lines in the southern hemisphere coincide more nearly with the parallels of latitude than in

the northern. In the Antarctic Ocean the only flexure is occasioned by the cold of the south polar current, which flows along the western coast of the American continent. In the northern hemisphere the predominance of land and its frequent alternations with water, the prevalence of particular winds, irregularities of the surface, and the difference in the temperature of the points of maximum cold, cause the isothermal lines to deviate more from the parallels of latitude. They make two deep bends northward, one in the Northern Atlantic and another in the north-east of America, and at last they separate into two parts, and encircle the points of maximum cold.

Professor Dove has discovered that, in consequence of the excess of land in the northern hemisphere, and the difference in the effect produced by the sun's heat according as it falls on a solid or liquid surface, there is an annual variation in the aggregate mean temperature at the surface of the earth, whose maximum takes place during the sun's northern declination, and its minimum during its southern.[1]

Places having the same mean annual temperature, often differ materially in climate: in some the winters are mild and the summers cool, whereas in others

[1] For example, Professor Dove has found that the mean temperature of December, January, and February, at Toronto in Canada, added to the mean temperature of the same months at Hobart Town in Van Diemen's Land, exceeds the sum of the mean temperature of June, July, and August, at the same places, added together, by 22°·7 of Fahrenheit. Similar results, though varying in amount, were obtained for many corresponding places in the two hemispheres, which establishes the law given in the text.

the extremes of heat and cold prevail: England is an example of the first; Quebec, St. Petersburg, and the Arctic regions are instances of the second. The solar heat penetrates more abundantly and deeper into the sea than into the land; in winter it preserves a considerable portion of that which it receives in summer, and from its saltness does not freeze so soon as fresh water; hence the ocean is not liable to the same changes of temperature as the land, and by imparting its heat to the winds it diminishes the severity of the climate on the coasts and in islands, which are never subject to such extremes of heat and cold as are experienced in the interior of continents. The difference between the influence of sea and land is strikingly exemplified in the high latitudes of the two hemispheres. In consequence of the unbounded extent of the ocean in the south, the air is so mild and moist that a rich vegetation covers the ground, while in the corresponding latitudes in the north the country is barren from the excess of land towards the Polar Ocean, which renders the air dry and cold. A superabundance of land in the equatorial regions, on the contrary, raises the temperature, while the sea tempers it.

Professor Dove has shown from a comparison of observations that northern and central Asia have what may be termed a true continental climate, both in summer and in winter—that is to say, a hot summer and cold winter; that Europe has a true insular or sea climate in both seasons, the summers being cool and the winters mild; and that in North

America the climate is inclined to be continental in winter, and insular in summer. The extremes of temperature in the year are greater in central Asia than in North America, and greater in North America than in Europe, and that difference increases everywhere with the latitude. In Guiana within the tropics the difference between the hottest and coldest months in the year is 2°·2 of Fahrenheit, in the temperate zone it is about 60°, and at Yakutsk in Siberia 114°·4. Even in places which have the same latitude as in northern Asia, compared with others in Europe or North America, the diversity is very great. At Quebec the summers are as warm as those in Paris, and grapes sometimes ripen in the open air, yet the winters are as severe as those in St. Petersburg. In short, lines drawn on a map through places having the same mean summer or winter temperature are neither parallel to one another, to the isothermal or geothermal lines, and they differ still more from the parallels of latitude.[1]

Observations tend to prove that all the climates

[1] In the same manner as isothermal lines are supposed to pass through all parts of the globe where the mean temperature of the air is the same, so the isogeothermal lines are supposed to pass through all places where the mean heat of the ground is the same: the isotherial lines are supposed to be drawn through all places having the same mean summer temperature; and the isochimenal lines pass through all places where the mean winter temperature is the same. The practice of representing to the eye these lines on a map or terrestrial globe is of the greatest use in following and understanding the complicated phenomena of temperature and magnetism.

on the earth are stable, and that their vicissitudes are only oscillations of greater or less extent, which vanish in the mean annual temperature of a sufficient number of years. There may be a succession of cold summers and mild winters, but in some other country the contrary takes place; the distribution of heat may vary from a variety of circumstances, but the absolute quantity gained and lost by the whole earth in the course of a year is invariably the same.

Since the air receives its warmth chiefly from the earth, its temperature diminishes with the height so rapidly, that at a very small elevation the cold becomes excessive, as the perpetual snow on the mountain-tops clearly shows. The decrease of heat is at the rate of a degree of Fahrenheit's thermometer for every 334 feet.

The atmosphere, being a heavy and elastic fluid, decreases in density upwards, according to a determinate law, so rapidly, that three-fourths of the whole air it contains are within four miles of the earth, and all the phenomena perceptible to us—as clouds, rain, snow, and thunder—occur within that limit. The air even on the tops of mountains is so rare as to diminish the intensity of sound, to affect respiration, and to occasion a loss of muscular strength in man and animals.[1]

Since the space in the top of the tube of a barometer

[1] If the heights above the earth increase by equal quantities, as a foot or a mile, the densities of the strata of air, or the heights of the barometer which are proportional to them, will decrease in geometrical progression: for example, if the height of the barometer at the level of the sea be 29·922

is a vacuum, the column of mercury is suspended in the tube by the pressure of the atmosphere on the surface of the mercury in the cistern: hence every variation in the density or height of the atmosphere occasions a corresponding rise or fall in the barometric column. The actual mean pressure of the atmosphere at the level of the sea is 15 pounds on the square inch; hence the pressure on the whole earth is enormous.

The decrease in the density of the air affords a very accurate method of finding the height of mountains above the level of the sea, which would be very simple, were it not for changes of temperature which alter the density and interfere with the regularity of the law of its decrease. But as the heat of the air diminishes with the height above the earth at the rate of one degree of Fahrenheit's thermometer for every 334 feet, tables are constructed by the aid of which heights may be determined with great accuracy. In consequence of diminished pressure also water boils at a lower temperature on mountain-tops than at the level of the sea, which affords another method of ascertaining heights.[1]

inches, it will be 14·961 inches at the height of 18,000 feet, or one-half as great; it will be one-fourth as great at the height of 36,000 feet, one-eighth at the height of 54,000 feet, and so on.

[1] A very ingenious little instrument, called the Aneroid Barometer, has been lately invented in France; which, at the same time that it forms an exact and very portable *weather*-glass in the common acceptation of that term, may be employed with considerable accuracy in ascertaining differences of level. Although not to be compared, as an instrument of precision, with the ordinary mercurial barometer, it

By the annual and diurnal revolutions of the earth, each column of air is alternately exposed to the heat and cold of summer and winter, of day and night, and also to variations in the attraction of the sun and moon, which disturb its equilibrium, and produce tides similar to those in the ocean. Those produced by the moon ebb and flow twice during a lunation, and diurnal variations in the barometer, to a very small amount, are also due to the moon's attraction.[1] The annual undulations occasioned by the sun have their greatest altitudes at the equinoxes, and their least at the solstices, and the diurnal variations in the height of the barometer, which accomplish their rise and fall twice in 24 hours, are chiefly due to the effects of temperature on the dry air and moisture of

is infinitely more portable, and gives with promptitude and accuracy small differences of level.

A friend of the author's has recently tested it in the latter respect on some of our railways, and found that observations made with it carefully will give, on a line of 200 miles in extent, the relative levels of the different stations within a few feet. The observations can be made in a couple of minutes. The gentleman in question writes to us, that he considers the Aneroid Barometer will prove a very useful instrument to the geological and the botanical traveller.

See, for a description of this instrument, a pamphlet recently published at 84, Strand, by Mr. E. J. Dent, on the Construction and Uses of the Aneroid Barometer. London, 1849.

[1] The moon's orbit is very much elongated, so that her distance from the earth varies considerably, and consequently her attractive force. Moreover her attraction varies with the rotation of the earth, which brings her twice in 24 hours in the meridian of any place, once in the superior and once in the inferior meridian; but her action on the atmosphere is much inferior to that of the heat of the sun.

the atmosphere, which, according to Mr. Dove's discoveries, produce independent pressures upon the mercurial column.

A quantity of vapour is continually raised by the heat of the sun from the surface of the globe, which mixes in an invisible state with the dry air or gaseous part of the atmosphere. It is most abundant in the torrid zone, and, like the heat on which it depends, varies with the latitude, the season of the year, the time of the day, the elevation above the sea, and also with the nature of the soil, the land, and the water. There is no chemical combination between the aërial and aqueous atmospheres, they are merely mixed; and the diurnal variations arise from the superposition of two distinct diurnal oscillations, each going through its complete period in 24 hours; one taking place in the aërial atmosphere from the alternate heating and cooling of the air, which produce a flux and reflux over the point of observation; the other arising from the aqueous atmosphere, owing to the alternate production and destruction of vapour by the heat of the day and the cold of the night. The diurnal variations of the vapour have their maximum at or near the hottest hour of the day, and their minimum at or near the coldest, which is exactly the converse of the diurnal variations of the dry air. On the whole there are two maxima and two minima heights of the barometer in the course of 24 hours from the combinations of these, but in the interior of continents far from water, where the air is very dry, there ought to be

one maximum and one minimum during that period according to this theory.

Between the tropics the barometer attains its greatest height at nine or half-past nine in the morning; it then sinks till four in the afternoon, after which it again rises and attains a second maximum at ten or half-past ten in the evening; it then begins to fall till it reaches a second time its lowest point at four in the morning. The difference in the height is 0·117 of an inch, which gradually decreases north and south. Baron Humboldt mentions that the diurnal variations of the barometric pressure are so regular between the tropics, that the hour of the day may be inferred from the height of the mercury to within fifteen or sixteen minutes, and that it is undisturbed by storm, tempest, rain, or earthquake, both on the coasts and at altitudes 13,000 feet above them. The mean height of the barometer between the tropics at the level of the sea is 30 inches with very little fluctuation, but, owing to the ascending currents of air from the heat of the earth, it is less under the equator than in the temperate zones. It attains a maximum in western Europe between the parallels of 40° and 45°; in the North Atlantic the maximum is about the 30th parallel, and in the southern part of that ocean it is near the tropic of Capricorn; the amplitude of the oscillations decreases from the tropics to about the 70th parallel, where the diurnal variations cease. They are affected by the seasons, being greatest in summer and least in winter. It appears also that the fluctuations are the reverse

on mountain-tops from what they are on the plains, and probably at a certain height they would cease altogether.[1] It is a singular fact, discovered by our navigators, that the mean height of the barometer is an inch lower throughout the Antarctic Ocean and at Cape Horn than it is at the Cape of Good Hope or Valparaiso: that difference in the pressure of the atmosphere is probably connected with the perpetual gales off the extremity of South America. M. Erman observed a similar depression near the Sea of Okhotsk in eastern Siberia.

Besides the small horary undulations, there are vast waves moving over the oceans and continents in separate and independent systems, being confined to local yet very extensive districts, probably occasioned by long-continued rains or dry weather over wide tracts of country. By numerous barometrical observations made simultaneously in both hemispheres, the courses of several have been traced, some of which take 24, others 36 hours, to accomplish their rise and fall. One especially of these vast barometric waves, many hundreds of miles in breadth, has been traced over the greater part of Europe, and not its breadth only, but also the direction of its front and its velocity, have been clearly ascertained. The course of another wave has been made out from the Cape of Good Hope, through many intermediate sta-

[1] Mr. Pentland has, however, found in the Peru-Bolivian Andes, at elevations between 11,000 and 14,000 feet, the horary oscillations of the barometer as regular, and nearly as extensive, as on the level of the sea in the same latitude.

tions, to the observatory at Toronto in Canada. Since every undulation has its perfect effect independently of the others, each one is marked by a change in the barometer, and this is beautifully illustrated by curved lines on paper, constructed from a series of observations. The general form of the curve shows the course of the principal wave, while small undulations in its outline mark the maxima and minima of the minor oscillations. Although, like all other waves, these in the atmosphere are but waving forms, in which there is no transfer of air, yet winds arise from them like tide-streams in the ocean, and Sir John Herschel is of opinion that the crossing of two of these vast aërial waves, coming in different directions, may generate at the point of intersection those tremendous revolving storms, or hurricanes, which spread desolation far and wide.

The air expands and becomes lighter with heat, contracts and becomes heavier with cold, and, as there are 82 degrees of difference between the equatorial and polar temperature, the light warm air at the equator is constantly ascending to the upper regions of the atmosphere, and flowing north and south to the poles, from whence the cold, heavy air rushes along the surface of the earth to supply its place between the tropics, for the same tendency to restore equilibrium exists in air as in other fluids. These two superficial currents, which have no rotatory motion when they leave the poles, are deflected from their meridional paths by friction from the continually increasing velocity of the earth's rota-

tion, as they come nearer and nearer to the tropics; and, as they revolve slower than the corresponding parts of the earth at which they arrive, the bodies on its surface strike against them with the excess of their velocity, so that the wind appears, to a person who thinks himself at rest, to blow in a direction contrary to that of the earth's rotation. For that reason the current from the north pole becomes a north-east wind before arriving at the tropic of Cancer, and that from the south pole becomes a south-east wind before it comes to the tropic of Capricorn, their limit being the 28th parallel of latitude on each side of the equator. In fact the difference of temperature puts the air in motion, and the direction of the resulting wind, at every place, depends upon the difference between the rotatory motion of the wind and the rotatory motion of the earth—the whole theory of the winds depends upon these circumstances.

Near the equator the trade-winds, north and south of it, so completely neutralize each other, that far at sea a candle burns without flickering. This zone of calms and light breezes, known as the *Variables*, which has a breadth of about five degrees and a half, is subject to heavy rains and violent thunder-storms. On account of the arrangement of land and water, it does not coincide with the equator, but its centre runs along the sixth parallel of north latitude; however, it changes in position and extent with the declination of the sun, but never crosses the line.

Though the trade-winds extend to the 28th de-

gree on each side of the equator, their limits vary considerably in different parts of the ocean, moving two or three degrees to the north or south, according to the position of the sun; and in the Atlantic the north-east trade-wind is less steady than the south-east.[1] These perennial winds are known by recent observation to be less uniform in the Pacific than in the Atlantic; they only blow permanently over that portion between the Galapagos Archipelago, off the coast of America, and the Marquesas. In the Indian Ocean the south-east trade-wind blows from a few degrees east of Madagascar to the coast of Australia, between 10° and 28° S. lat. The trade-winds are only constant far from land, because continents and islands intercept them, and change their course. On that account the numerous groups of islands westward from the Marquesas change the trade-winds into the periodical monsoons, which are steady currents of air in the Arabian Gulf, the Indian Ocean, and China Sea, arising from diminished atmospheric pressure at each tropic alternately, from the heat of the sun, thereby producing a regular alternation of north and south winds,

[1] Lieutenant Maury, of the United States navy, is led to believe that there is a region within the limit of the N.E. trade-winds, in the Atlantic, in which the prevailing winds are from the south and west: this region is somewhat in the shape of a wedge, with its base towards the coast of Africa, between the equator and 10° N. lat., and between the meridians of 10° and 25° W. long. In this space, in which the law of the trade-winds is reversed, there are great atmospheric disturbances, violent squalls, sudden gusts of wind, thunder, storms, heavy rains, baffling airs, and calms.

which, combining with the rotation of the earth on its axis, become a north-east wind in the northern hemisphere, and a south-east in the southern. The former blows from April to October, the latter from October to April; the change is accompanied by heavy rain and violent storms of thunder and lightning. The ascent of the warm air between the tropics occasions a depression of the barometer amounting to the tenth of an inch, which is a measure of the force producing the trade-winds. In both hemispheres there is a regular variation in the mean height of the barometer within the zone in which these great aërial currents flow; it is higher at their polar limits, and decreases with extreme uniformity towards their equatorial boundaries, the difference in both hemispheres being 0·25 of an inch.

The unequal temperature of the land and sea causes sea-breezes which blow towards the land during the day, and land-breezes which blow sea-ward in the night; they are not perceptible in the mornings and evenings, because the temperature of the land and water is then nearly the same.

The trade-winds and monsoons are permanent, depending on the apparent motion of the sun; but it is evident from theory that there must be partial winds in all parts of the earth, occasioned by the local circumstances that affect the temperature of the air. Consequently the atmosphere is divided into districts, both over the sea and land, in which the winds have nearly the same vicissitudes from year to year. The regularity is greatest towards

the tropics, where the causes of disturbance are fewer. In the higher latitudes it is more difficult to discover any regularity, on account of the greater proportion of land, the difference in its radiating power, and the greater extremes of heat and cold. But even there a degree of uniformity prevails in the succession of the winds; for example, in all places where north and south winds blow alternately, a vane veers through every point of the compass in the transition, and in some places the wind makes several of these gyrations in the course of the year.[1] The south-westerly winds so prevalent in the Atlantic Ocean between the 30th and 60th degrees of north latitude are produced by the upper current being drawn down to supply the superficial current which goes towards the equator, and, as it has a

[1] In the northern hemisphere a north wind sets out with a less rotatory motion than the places have at which it successively arrives, consequently it veers through all the points of the compass from N. to N.E. and E. If a south wind should now spring up, it would gradually veer from S. to S.W. and W., because its rotatory velocity would be greater than that of the places it successively comes to. The combination of the two would cause a vane to veer from E. to S.E. and S.; but the rotation of the earth would now cause the south wind to veer round from S. to S.W. and W.; and should a north wind now arise, its combination with the west wind would bring the vane round from W. to N.W. and N. again. At the Greenwich Observatory the wind makes five gyrations in that direction in the course of a year. In Europe it is the contention of the N.E. and S.W. winds which causes the rotation of the wind, and the principal changes of weather, the S.W. being warm and moist, the N.E. cold and dry, except where it comes over the German Ocean.

greater rotatory motion than the earth in these latitudes, it produces a south-westerly wind. On this account the average voyage from Liverpool to New York in a sailing vessel is 40 days, while it is only 23 days from New York to Liverpool. For the same reason the average direction of the wind in England, France, Germany, Denmark, Sweden, and North America, is some point between south and west. North-westerly winds prevail in the corresponding latitudes of the southern hemisphere from the same cause. In fact, whenever the air has a greater velocity of rotation than the surface of the earth, a wind more or less westerly is produced; and when it has less velocity of rotation than the earth, a wind having an easterly tendency results. Thus there is a perpetual change between the different masses of the atmosphere, the warm air tempering the cold of the higher latitudes, and the cold air mitigating the heat of the lower; it will be shown afterwards that the aërial currents are the bearers of principles on which the life of the animal and vegetable world depends.

Hurricanes are those storms of wind in which the portion of the atmosphere that forms them revolves in a horizontal circuit round a vertical or somewhat inclined axis of rotation, while the axis itself, and consequently the whole storm, is carried forwards along the surface of the globe, so that the direction in which the storm is advancing is quite different from the direction in which the rotatory current may be blowing at any point; the progressive motion ma

continue for days, while the wind accomplishes many gyrations through all the points of the compass in the same time. In the Atlantic the principal region of hurricanes is to the east of the West Indian islands, and in the Pacific it lies east of the island of Madagascar; consequently the former is in the northern hemisphere, the latter in the southern; but in every case the storm moves in an elliptical or parabolic curve. The West Indian hurricanes generally have their origin eastward of the Lesser Antillas or Caribbean islands, and the vertex of their path near the tropic of Cancer, or about the exterior limit of the north-east trade-wind. As the motion of the storm before it reaches the tropic is in a straight line from S.E. to N.W., and after it has passed the tropic from S.W. to N.E., the bend of the curve is turned towards Florida and the Carolinas. In the South Pacific Ocean the body of the storms moves in an exactly opposite direction. The hurricanes which originate south of the equator, and whose initial path is from N.E. to S.W., turn at the tropic of Capricorn and then tend from N.W. to S.E., so that the bend of the curve is turned towards Madagascar.

The extent and velocity of the Atlantic hurricanes are great; the most rapid move at the rate of 43 miles an hour, the slowest 16. The hurricane which took place on the 12th of August, 1830, was traced from the eastward of the Caribbean islands to the banks of Newfoundland, a distance of more than 3000 miles, which it passed over in six days. Al-

though that of the 1st of September, 1821, was not so extensive, its velocity was greater, as it moved at the rate of 30 miles an hour. Small storms are generally more rapid than those of great magnitude. Sometimes they appear to be stationary, sometimes they stop and again proceed on their course, like water-spouts. Hurricanes are occasionally contemporaneous, and so near to one another as to travel in almost parallel tracks. This happened in the China seas in October, 1840, when the two storms met at an angle of 47°, and it was supposed that the ship Golconda foundered in that spot with 300 people on board. A hurricane has been split or divided by a mountain into two separate storms, each of which continued its new course, and the gyrations were made with increased violence. This occurred in the gale of the 25th of December, 1821, in the Mediterranean, when the Spanish mountains and the maritime Alps became new centres of motion.

By the friction of the earth the axis of the storm bends a little forward, and the whirling motion begins in the higher regions of the atmosphere before it is felt on the earth: this causes a continual intermixture of the lower and warmer strata of air with those that are higher and colder, producing torrents of rain, and sometimes violent electric explosions.

The rotation as well as the course of the storm is in a different direction in the two hemispheres, though always alike in the same. In the northern hemisphere the gyration is contrary to the movement of the hands of a watch, that is to say, the

wind revolves from east, through the north, to west, south, and east again; while in the southern hemisphere the rotation about the axis of the storm is in the contrary direction. Hurricanes happen south of the equator between December and April; in the West Indies, between June and October. Rotatory storms frequently occur in the Indian Ocean, and the typhoons of the China seas are real hurricanes of great violence. Both conform to the laws of such winds in the northern hemisphere. The Atlantic storms probably reach Spain, Portugal, and the coast of Ireland. Two circular storms have passed over Great Britain, and small ones often occur between the Chops of the Channel and Madeira.

The revolving motion accounts for the sudden and violent changes observed during hurricanes. In consequence of the rotation of the air, the wind blows in opposite directions on each side of the axis of the storm, and the violence of the blast increases from the circumference towards the centre of gyration, but in the centre itself the air is in repose: hence, when the body of the storm passes over a place, the wind begins to blow moderately, and increases to a hurricane as the centre of the whirlwind approaches; then in a moment a dead and awful calm succeeds, suddenly followed by a renewal of the storm in all its violence, but now blowing in a direction diametrically opposite to what it had before: this happened in the island of St. Thomas on the 2nd of August, 1837, where the hurricane increased in violence till half-past seven in the morning, when

perfect stillness took place for 40 minutes, after which the storm recommenced in a contrary direction. The breadth of a hurricane is greatly augmented when its path changes its direction in crossing the tropic. In the Atlantic the vortex of one of these tempests has covered an area from 600 to 1000 miles in diameter. The breadth of the lull in the centre varies from 5 to 30 miles: the height is from 1 to 5 miles at most; so that a person might see the strife of the elements from the top of a mountain, such as Teneriffe or Mowna Roa, in a perfect calm, for the upper clouds are frequently seen to be at rest during the hideous turmoil in the lower regions.

The sudden fall of the mercury in the barometer in latitudes habitually visited by hurricanes is a certain indication of a coming tempest. In consequence of the centrifugal force of these rotatory storms, the air becomes rarified, and, as the atmosphere is disturbed to some distance beyond the actual circle of gyration or the limits of the storm, the barometer often sinks some hours before its arrival; it continues sinking the first half of the hurricane, and again rises during the passage of the latter half, though it does not attain its greatest height till the storm is over. The diminution of atmospheric pressure is greater, and extends over a wider area, in the temperate zones than in the torrid, on account of the sudden expansion of the circle of rotation where the gale crosses the tropic.

As the fall of the barometer gives warning of the

approach of a hurricane, so the laws of the storm's motion afford to the seaman knowledge to avoid it. In the northern temperate zone, if the gale begins from the S.E. and veers by S. to W., the ship should steer to the S.E.; but if the gale begins from the N.E. and changes through N. to N.W., the vessel ought to go to the N.W. In the northern part of the torrid zone, if the storm begin from the N.E. and veer through E. to S.E., the ship should steer to the N.E.; but if it begin from the N.W. and veer by W. to S.W., the ship should steer to the S.W., because she is on the south-western side of the storm. Since the laws of storms are reversed in the southern hemisphere, the rules for steering vessels are necessarily reversed also.[1]

A heavy swell or storm-wave is peculiarly characteristic of these tempests. In the centre of the hurricane the pressure of the atmosphere is so much diminished by rotation, that the mercury in the ba-

[1] In all hurricanes hitherto observed, the sinking of the mercury, and the increase of the wind, have been more or less regularly progressive till within three or four hours' sail of the centre of the storm; and in one class they have continued so even to the centre; while in another class, and by far the most terrible, the depression of the mercury has been sudden and excessive when within that distance of the centre, and the violence of the tempest far beyond the average. When a ship is within 50 or 60 miles of the centre, the storm has the mastery, and seamanship is of little avail. Rules for avoiding this calamity, and for managing a ship when involved in a hurricane, are fully explained in the 'Sailor's Horn-Book for the Laws of Storms,' by H. Piddington, Esq., President of the Marine Courts of Inquiry at Cal-

rometer falls from one to two, and even two and a half inches. On that account the pressure of the ocean beyond the range of the wind raises the water in the centre of the vortex about two feet above its usual level, and proportionally to the degree of diminished pressure over the whole area of the storm. This mass of water, or storm-wave, is driven bodily along with, or before, the tempest, and rolls in upon the land like a huge wall of water. It is similar to the earthquake-wave, and is by no means the heaping up of the water after a long gale. Ships have been swept by it out of docks and rivers, and it has sometimes carried vessels over reefs and banks so as to land them high and dry; this happened to two ships on the coast of the Eastern Andaman islands, in 1844. Coringa, on the Coromandel coast, is particularly subject to inundations from that

cutta. The following approximate table is given by him, to serve as a guide till better data shall be obtained:—

Average fall of the barometer per hour.		Distance of a ship from the centre of the storm, in miles.
From 0·020 to 0·060	. .	From 250 to 150
„ 0·060 „ 0·080	. .	„ 150 „ 100
„ 0·080 „ 0·120	. .	„ 100 „ 80
„ 0·120 „ 0·150	. .	„ 80 „ 50

The rate of fall per hour doubles after the storm has lasted six hours, and within three hours of the centre of the hurricane the mercury will fall four times as fast, if it be of the violent class.

Colonel James Capper discovered the rotatory motions of storms, and W. C. Redfield, Esq., of New York, was the first who determined their laws. Colonel Reid, Governor of Barbadoes, and Dr. Thom, of the 86th regiment, have also written on the subject.

cause. In 1789 the town and 20,000 inhabitants were destroyed by a succession of these great waves during a hurricane, and as many perished there in 1839.

Besides storm-waves, storm-currents are raised, which revolve with the rotation of the wind, and are of the greatest force near the centre of the vortex.

The rise of the sea by the pressure of the surrounding ocean, and the irresistible fury of the wind, makes a tremendous commotion in the centre of the storm, where the sea rises, not in waves, but in pyramidal masses : the noise during its passage resembles the deafening roar of the most tremendous thunder; and in the typhoons in the China seas it is like numberless voices raised to the utmost pitch of screaming. In general there is very little thunder and lightning; sometimes a vivid flash occurs during the passage of the centre, or at the beginning of the storm; yet in Barbadoes the whole atmosphere has been enveloped in an electric cloud.

A thick lurid appearance, with dense masses of cloud in the horizon, ominous and terrible, are the harbingers of the coming tempest. The sun and clouds frequently assume a fiery redness, the whole sky takes a wild and threatening aspect, and the wind rises and falls with a moaning sound, like that heard in old houses on a winter's night: it is akin to the "calling of the sea," a melancholy noise which, in a dead calm, presages a storm on some parts of the English coast.

Those intensely violent gales, of short duration, called *arched squalls*, because they rise from an

arch of clouds on the horizon, are not rotatory; they occur in the Straits of Malacca, attended by fierce thunder and lightning and a lurid phosphorescent gleam. The north-western gales in the Bay of Bengal, the tornadoes on the African coast, and the pamperos of the Rio de la Plata, are of the same nature. On an average a strong gale moves at the rate of 40 miles an hour, a storm at about 56, and hurricanes at 90.

Whirlwinds are frequent in tropical countries, especially in deserts; sometimes several are seen at one time in the Arabian deserts, of all sizes, from a few feet to some hundred yards in diameter. They occur in all kinds of weather, by night as well as by day, and come without the smallest notice, rooting up trees, overwhelming caravans, and throwing down houses; and as they produce water-spouts when they reach the sea, they dismantle and even sink ships. The water-spouts so frequently seen on the ocean originate in adjacent strata of air of different temperatures, running in opposite directions in the upper regions of the atmosphere. They condense the vapour, and give it a whirling motion, so that it descends tapering to the sea below, and causes the surface of the water to ascend in a pointed spiral till it joins that from above, and then it looks like two inverted cones, being thinner in the middle than either above or below. When a water-spout has a progressive motion, the upper and under part must move in the same direction, and with equal velocity, otherwise it breaks, which frequently happens.

CHAPTER XXII.

Evaporation — Distribution of Vapour — Dew — Hoar Frost — Fog — Region of Clouds — Forms of Clouds — Rain — Distribution of Rain — Quantity — Number of rainy Days in different Latitudes — Rainless Districts — Snow Crystals — Line of perpetual Snow — Limit of Winter Snow on the Plains — Sleet — Hail — Minuteness of the ultimate Particles of Matter — Their Densities and Forms — Their Action on Light — Colour of Bodies — Colour of the Atmosphere — Its Absorption and Reflection of Light — Mirage — Fog Images — Coronæ and Halos — The Rainbow — Iris in Dewdrops — The Polarization of the Atmosphere — Atmospheric Electricity — Its Variations — Electricity of Fogs and Rain — Inductive Action of the Earth — Lightning — Thunder — Distribution of Thunder-Storms — Back Stroke — St. Elmo's Fire — Phosphorescence — Aurora—Magnetism—Terrestrial Magnetism — The Dip — Magnetic Poles and Equator—Magnetic Intensity—Dynamic Equator — Declination — Magnetic Meridian — Lines of equal Variation — Horary Variations — Line of Alternate Horary Phenomena — Magnetic Storms — Coincidence of the Lines of equal Magnetic Intensity with Mountain Chains — Diamagnetism.

MOISTURE is evaporated in an invisible form from every part of the land and water, and at all temperatures, even from snow. Mr. Darwin mentions that the snow once entirely disappeared from the volcano of Aconcagua, in Chile, which is 23,300 feet high, from evaporation under a cloudless sky and an excessively dry air. The vapour rises and mixes with the atmosphere; and as its pressure and density dimi-

nish with the height above the surface of the earth, in consequence of gravitation, there is absolutely less moisture in the higher than in the lower regions of the air.

Seven-tenths of the atmosphere rests on the ocean; therefore the sea has the greatest influence in modifying climates and supplying the air with moisture. The evaporation is greatest between the tropics, from the excess of heat and the preponderance of the ocean, and its average quantity decreases from thence to the poles. Over the open sea, in all latitudes, the air is saturated with moisture; and in that over the coasts the quantity is very great, but it diminishes from the coasts to the interior of the continents. In the interior of the United States of North America, in the deserts of Asia, and in the interior of New Holland, the air is continually dry. There is scarcely any evaporation in the deserts of Africa, and the extreme heat, increased by the reverberation of the sand, opposes aqueous precipitations, so this land is doomed to perpetual sterility. The air over the steppes of Siberia is likewise nearly deprived of moisture. The greatest degree of dryness on record is that observed by M. Erman between the valleys of the Irtish and Obi, after a continued south-west wind and a temperature of 74° 7′ of Fahrenheit.

Throughout all the countries in the northern hemisphere where observations have been made on the variations of atmospheric moisture, it appears that the air contains less vapour in January than in any other month of the year, yet at that time there is the

greatest dampness; while in July the air is driest, and yet, on account of the heat, evaporation is the greatest: the reason is, that the heat in July dissolves the moisture and increases its elasticity or tension so much that it becomes insensible, whereas the cold of winter condenses it and renders it apparent.

The quantity of atmospheric moisture varies also with the hours of the day and night. In early morning the evaporation accumulates near the surface of the ground from the resistance of the air above it, but as the sun rises above the horizon the warm air descends and carries the vapour with it; so that the quantity near the ground is diminished till evening, when, on account of the lowness of the temperature, the ascending currents cease, and the air becomes loaded with vapour and deposits its excess in the shape of dew or hoar-frost. For in the night the earth radiates part of the heat it received during the day through the atmosphere into space, and the temperature of the bodies on its surface sinks below that of the air; and by abstracting part of the heat which holds the humidity of the air in solution a deposition takes place. If the radiation be great, the dew is frozen and becomes hoar-frost, which is the ice of dew. Cloudy weather is unfavourable for the formation of dew by preventing the free radiation of heat, and actual contact is necessary for its formation, as it is never suspended in the air like fog. Dew falls in calm serene nights, but not on all substances indifferently; it wets them in proportion to their powers of radiation, leaving those dry that radiate feebly or

not at all. Dew is most abundant on coasts; in the interior of continents there is very little, except near lakes or rivers. When dew is congealed into hoar-frost it forms beautiful crystals, and the cold which produces it is very hurtful to vegetation, but a slight covering preserves plants from its effects.

When the atmosphere is so saturated with the vapour of water that it is precipitated in the air itself, a fog is the result, which consists of small globular particles of water. When dew is formed the earth is colder than the air in contact with it; but the case is exactly the contrary when fogs take place, the moist soil being warmer than the air. In countries where the soil is moist and warm, and the air damp and cold, thick and frequent fogs arise, as in England, where the coasts are washed by a sea of elevated temperature, and the excess of the heat of the Gulf-stream above the cold moist air is the cause of the perpetual fogs in Newfoundland.

Superior to all these phenomena, and at a considerable height above the earth, the air is very dry, because, under ordinary circumstances, the vapour ascends in a highly elastic and invisible state till it reaches a stratum of air of lower temperature, and then it is condensed into clouds. The region of clouds is a zone at a height varying from one to four miles above the surface of the earth, which is saturated with moisture. From friction and other causes the currents of air in the lower parts of that zone run horizontally on each other; and as they generally differ in moisture, temperature, and velocity, the

colder condense the invisible vapour in the warmer, and make it apparent in the form of a cloud, which differs in no respect from a fog, except that one floats high in the air, while the other rests on the ground.

At moderate heights clouds consist of vapour, but at great elevations where the cold is severe they are an assemblage of minute crystals of ice. They assume three primary characters, from whence four subordinate forms are derived. The cirrus, or cat's-tail of sailors, is the highest; it sometimes resembles a white brush, at other times it consists of horizontal bands of slender silvery filaments. To these all Kämtz's measurements assign a height of 19,500 feet, which is confirmed by their appearance being the same when seen from the tops of mountains or from the plains; consequently they must consist of minute particles of ice or flakes of snow floating in the higher regions of the zone of clouds. The cirri for the most part arrange themselves in parallel bands which converge to opposite points in the horizon by the effects of perspective, and as they travel in their longitudinal direction they appear to be stationary. In the middle and higher latitudes of the northern hemisphere they tend from south-west to north-east, and at the equator from south to north. It is supposed that their parallel form arises from their being conductors between two foci of electricity, but, whatever the cause of this arrangement may be, it is very extensive. Among these clouds, which occasionally appear like fleecy cotton

or wool, halos and parhelia are formed, which often precede a change of weather, announcing rain in summer, in winter frost and snow.

Cumuli or summer-clouds are rounded forms resting on a straight band in the horizon, and resemble mountains covered with snow. They are formed by ascending currents drawing the vapours into the higher regions of the atmosphere; sometimes they rise and cover the whole sky, and in the evening they frequently become more numerous and of deeper tint, presaging storm or rain.

The stratus is the third of the primary characters of clouds: it is a horizontal band, which forms at sunset and vanishes at sunrise. The subordinate varieties of clouds are combinations of these three principal classes.[1] The winds, the great agents in all atmospheric changes, carry the vapour to a distance, where it is often condensed on the tops of mountains into clouds which seem to be stationary, but which in reality are only maintained by a constant condensation of fresh vapour, which is carried

[1] The four subordinate forms of clouds are the cirro-stratus, composed of little bands of filaments, more compact than the cirrus, forming horizontal strata, which seem to be numerous thin clouds when in the zenith, and at the horizon a long narrow band. The cumulo-stratus consists of the summer-cloud, like snowy mountains heaped on one another, which at sunrise have a black or bluish tint at the horizon, and pass into the nimbus, or rain-cloud, which has a uniform grey tint, fringed at the edges; and the fourth is the cirro-cumulus, a combination of filaments and heaped-up cumuli or summer-clouds.

off, as soon as formed, by the wind, and becomes invisible on entering warmer air.

When two masses of air of different temperature meet, the colder, by abstracting the heat which holds the moisture in solution, causes the particles to coalesce and form drops of water, which fall in the shape of rain by their gravitation. And when two strata of different temperature moving rapidly in contrary directions come into contact, a heavy fall of rain takes place; and as the quantity of aqueous vapour is most abundant in tropical regions, the drops are larger and the rain heavier than elsewhere.

Since heat is the cause of evaporation, rain is very unequally distributed, and with it decreases from the equator to the poles. From the island of Otaheite, in the Pacific, to Uleaborg, in Finland, the annual quantity of rain that falls decreases from 150 inches to 13. It is, however, more abundant in the New World than in the Old; 115 inches fall annually in tropical America, while in the Old World the annual fall is only 76 inches; so also in the temperate zone of the United States the annual quantity is 37 inches, while in the Old Continent it is but 31¾ inches.

Between the tropics the rains follow the sun: when he is north of the equator the rains prevail in the northern tropic; and when he is south of that line, in the southern: hence one half of the year is extremely wet and the other half extremely dry; the change taking place near the equinoxes. Nevertheless, in countries situate between the 5th and 10th

parallels of latitude, north and south, there are two rainy seasons, and two dry; one occurs when the sun passes the zenith in his progress to the nearest tropic, and the other at his return, but in the latter the rains are less violent and of shorter duration. Although the quantity of water which falls between the tropics in a month is greater than that of a whole year in Europe, yet the number of rainy days increases with the latitude, so that there are fewest where the quantity is greatest. Neither does it fall continually during the rainy season between the tropics, for the sky is generally clear at sunrise, it becomes cloudy at ten in the morning, at noon the rain begins to fall, and, after pouring for four or five hours, the clouds vanish at sunset, and not a drop falls in the night, so that a day of uninterrupted rain is very rare.

At sea within the region of the trade-winds it seldom rains, but in the narrow zone between them known as the *Variables*, in both the great oceans, it rains almost continually, attended by violent thunder and lightning.

Throughout the whole region where the monsoons prevail, it is not the sun, directly, but the winds, that regulate the periodical rains. That region extends from the eastern coasts of Africa and Madagascar across the Indian Ocean to the northern districts of Australia, and from the tropic of Capricorn to the face of the Himalaya, the interior of China, and even to Corea, inclusive. In these countries the western coasts are watered during the south-west monsoc

which prevails from April to October; and the eastern coasts are watered during the north-east monsoon, which blows from October to April. For example, the south-west wind condenses the vapour on the summit of the Ghauts, and violent rains fall daily on the coast of Malabar, while on the Coromandel coast the sky is serene. Exactly the contrary takes place during the north-east monsoon; it rains on the coast of Coromandel, while there is fair weather on the Malabar coast, and the table-land of the Deccan partakes of both. In the southern hemisphere the rainy season corresponds with the south-west monsoon, and the dry with the south-eastern.

Between the tropics it rains rarely during the night, and for months together not a drop falls; while in the temperate zone it often rains in the night, and rain falls at all seasons, though more abundantly in some than in others. It seldom rains in summer throughout the north of Africa, Madeira, the southern parts of Spain and Portugal, Sicily, southern Italy, all Greece, and the north-western part of Asia; but it falls copiously during the other seasons, especially in winter; consequently that extensive region is called the province of winter rains.

The province of autumnal rains includes all Europe south of the Carpathians, western France, the delta of the Rhine, northern and western Scandinavia, and the British isles; throughout these countries more rain falls in autumn than in the other three seasons.

The province of summer rains comprises the

eastern parts of France, the Netherlands (with the exception of the delta of the Rhine), the north of Switzerland, all Germany north of the Alps, the Carpathian mountains, Denmark, southern Scandinavia, all central Europe, and the countries beyond the Ural Mountains to the interior of Siberia, where showers are very rare in winter. In some places it rains almost perpetually, as in the island of Sitka, on the north-eastern coast of North America, where the year has sometimes passed with only 40 days of fair weather.

In the southern hemisphere, in Chile and the south-western part of America, winter is the rainy season, while on the eastern side of the Cordilleras the rains occur in summer. In Tierra del Fuego and the extreme point of the continent the two provinces meet, the periodical precipitation disappears, and it snows and rains throughout the year in torrents. At Cape Horn the quantity of rain which fell in 41 days measured nearly 154 inches. This excessive fall of rain occurs along the whole western shores of Patagonia, from the Straits of Magellan to Cape Tres Montes—a circumstance favoured by the high and rugged coasts, and the incessant westerly winds, which carry the vapour exhaled from the ocean to be precipitated here in the form of rain.

South Africa and Australia resemble each other in their rainy seasons, which in both countries take place in the winter months.

The annual amount of rain at the equator is 95 inches, which falls in 78 or 80 days, giving

average of 1·14 inch daily; while at St. Petersburg the annual amount is 17 inches, which falls in 169 days, the average being little more than the tenth of an inch daily.

The quantity of rain decreases in ascending from the plains to table-lands, especially if these be edged by mountains, because they precipitate the vapour before it arrives at the high plains. On the contrary, the quantity increases in ascending from plains to the tops or slopes of rugged mountains, on account of partial currents of air which condense the moisture into clouds.

The quantity of rain decreases on receding from the coasts into the interior of continents, because more vapour rises from the sea than from the land. The vapour from the Gulf-stream produces a greater quantity of rain and fog in the southern counties of England and Ireland than that which falls in the other parts of the islands.

The number of rainy days depends upon the direction of the wind. In Europe, if the wind always blew from the north-east, it would never rain, because it blows over a great extent of continent; whereas it would never cease raining were the wind always to blow from the south-west, because it would come loaded with vapour from the Atlantic. Hence the greatest quantity of rain falls on the west coasts of Great Britain and Ireland, the coast of Scandinavia, the Eastern Alps, and the centre of Portugal; in the two last it depends partly on the height and serrated form of the mountains. In western Europe it rains

on twice as many days as in the eastern part; in Ireland there are three times as many rainy days as in Italy or Spain. In fact, on the western side of Ireland it rains on 208 days out of the 365. In England, France, and the north of Germany, there are from 152 to 155 rainy days in the year; the number decreases towards the interior of the continent, so that in Siberia it only rains on 60 days in the year.

There are enormous tracts of land on which rain never falls, and others where it rains at long intervals and in small quantities. The most extensive rainless district stretches from the borders of Morocco eastward through the desert of Africa, the low coasts of Arabia, Persia, and the desert province of Meekran, in Beloochistan, occupying a space of 80 degrees of longitude and 17 of latitude. The desert of Gobi, on the table-land of Tibet, and part of Mongolia, form another rainless province in the great continent; while, in the New World, the rainless districts are—the table-land of Mexico, part of Guatemala and California, and the western declivity of the Andes of Peru, towards the Pacific; in all occupying a surface equal to 5,500,000 square miles. The whole of the moisture is intercepted by the Andes of Peru; so that rain only occurs on the coast once or twice in a century—to the great terror of the inhabitants when it does fall. South Africa, and Australia beyond the tropics, suffer from droughts, which are periodical in Australia; they recur in the countries of the eastern coasts in a

period of 12 years, and continue 3 years. The Pampas of South America are also subject to droughts, though they do not appear to be periodical, nor do they continue more than a season.[1]

When the temperature of the air is near the freezing point or below it, snow falls instead of rain; but the colder the air the less moisture does it contain, consequently the less snow falls, which is the reason of the comparatively small quantity on the high plains of the Himalaya and Andes. Snow sometimes assumes the form of grains; but is generally in regular crystals of great beauty, varying in form according to the degree of cold. Captain Scoresby, whose voyages in the Polar Seas afforded him constant opportunities of studying them, of which he so diligently availed himself, mentions five principal kinds of snow crystals, each of which had many varieties, in all amounting to 96. M. Kämtz, however, is of opinion that there are several hundred.

Snow never falls between the tropics except on the tops of very high mountains. The mean elevation of the line of perpetual snow above the level of the sea in these hot regions is about 15,207 feet, from whence it decreases on both sides, and at last grazes the surface of the earth at the arctic and antarctic circles, subject however to various flexures. In the Andes, near Quito, the lowest level has an elevation of 15,795 feet, which is higher than the

[1] The reader is referred to the chart of the distribution of rain in the Physical Atlas of Alexander Keith Johnston, Esq., where the value of the practice referred to in note p. 27 is shown.

top of Mont Blanc; from thence it varies very irregularly, both to the north and south. In 18° of N. lat. it descends to 14,772 feet on the mountains of Mexico, while on the south it rises to 18,000 feet in some parts of the western Cordillera of the Bolivian Andes, owing to the extensive radiation from the subjacent plains and valleys. The line is at an altitude of 17,000 feet on the western Cordillera, whence it sinks to 13,800 feet at Copiapo, to 12,780 near Valparaiso; it is only 8300 in the southern end of the Chilian Andes, and 3390 in the Straits of Magellan. In lat. 31° N. the snow-line is at an elevation of 12,981 feet on the southern side of the Himalaya, and at 16,620 feet on the northern side, while Captain Gerard gives from 18,000 to 19,000 as its altitude on the mountains in the middle of the plain of Tartary. On Mont Blanc the line is at the height of 8500 feet, so that mountain is snow-clad for 7000 feet below its summit. In the Pyrenees it is 8184 feet, and at the island of Mageroe it is at 2160 feet, above the Polar Ocean.

In the southern hemisphere snow never falls on the low lands at the level of the sea north of the 48th parallel of latitude, on account of the predominance of water, whereas in the northern hemisphere it falls on the plains much nearer the equator, on account of the excess of land, but its limit is a curved line, on account of the alternations of land and water. In the western part of the great continent the southern limit of the fall of snow on the low lands nearly coincides with the 30th parallel of

north latitude, so that it includes all Europe. In the American continent it follows nearly the same line, extending through the southern parts of the United States. In China snow falls at the level of the sea as far south as Canton; on the north-western coast of America, on the contrary, it does not fall at that level till about the 48th degree of N. lat.—these are the two extremes. Although Europe lies within the region of snow, the quantity that falls is very different in different places, increasing greatly from south to north. On an average it snows only one day and a half at Rome in the year, while at Petersburg there are 171 snowy days, but in that city the quantity of rain is to that of snow as 1000 to 384.

Sleet, which is formed of small particles of rounded hail, falls in squally weather in spring and autumn. True hail, when large, is pear-shaped, and consists of a nucleus of frozen snow coated with ice, and sometimes with alternate layers of snow and ice. Hailstones have often fallen as large as pigeons' and even hens' eggs. The masses and blocks of ice of great size, which have not unfrequently fallen, appear to have been formed of hailstones of large size frozen together. It appears to be formed in the high cold regions of the atmosphere, by the sudden condensation of vapour during the contention of opposing winds, and is intimately connected with electricity, since its fall is generally accompanied with thunder and lightning. Hail-showers are of short duration, exceedingly partial, and extend over a country in long narrow bands; one which took

place on the 13th of July, 1788, began in the morning in the south of France, and reached Holland in a few hours, destroying a narrow line of country in its passage.

Local circumstances, no doubt, have a great influence on its formation; it occurs more frequently in countries at a little distance from mountains than in those close to them or farther off, and at all hours, but most frequently at the hotter time of the day. In the interior of Europe one half of the hail-storms take place in summer. Hail is very rare on the tropical plains, and often altogether unknown, though it frequently falls at heights of 1700 or 1800 feet above them. If the air is very cold throughout the greater part of the stratum through which hail falls, it is probably increased in size during its descent; and, on the contrary, large drops of rain which precede a thunder-storm are supposed to be hail melted in its passage through low warm air.

LIGHT.

We know nothing of the size of the ultimate particles of matter, except that they must be inconceivably small, since organized beings possessing life and exercising all its functions have been discovered so minute that a million of them would occupy less space than a grain of sand.

The air is only visible when in mass; the smallest globule of steam tells no more of its atoms than the ocean; the minutest grain of sand magnified appears like the fragment of a rock—no mechanical division

can arrive at the indivisible. Although the ultimate atoms are beyond the power of vision, chemical compounds show that the divisibility of matter has a limit, and that the particles have different densities; moreover the cleavage of crystalline substances gives reason to believe that they have different forms.[1] Thus the reasoning power of man has come to the aid of his imperfect sense of vision, so that what were before imaginary things are now real beings with definite weights, and uniting by fixed laws. Though nothing had been known of their size, their effects were evident in the perceptions of sweet and sour, salt and bitter, and in the endless varieties of aroma in the food we eat and the liquors we drink. Moreover, their different densities are evident, as they arise by their buoyancy in the perfume of the rose, or sink by their weight in the heavy odour of mignonette. Every substance on earth is merely a temporary compound of the ultimate atoms, sooner or later to be resolved into its pristine elements, which are again to be combined in other forms, and according to other laws; so that literally there is nothing new under the sun, for there is no evidence of new matter being added to the earth, nor of that which exists being annihilated. Fire, which seems utterly to destroy, only resolves bodies into their elementary parts, to become what they were before, the support of animal or

[1] The reader is referred to the 'Connexion of the Physical Sciences' for an account of Dr. Dalton's theory of definite proportions, and the relative weight of atoms.

vegetable life, or to form new mineral compounds. It is to the action of these particles on the light of the sun that nature owes all its colours.

When a sunbeam passes through a glass prism[1] an oblong image of the sun is formed consisting of colours in the following order—red, orange, yellow, green, blue, indigo, and violet. Sir John Herschel discovered lavender rays beyond the violet, and dark red rays exterior to the red, which are not so easily brought into evidence as the rest.

Even the most transparent substances absorb light; air, water, the purest crystal, stop some of the rays as they pass through them. A portion of the light is also reflected from the surface of all bodies; were it otherwise, they would be invisible. We should be unconscious of the presence and form of material substances beyond our reach except by the reflected rays,—

> "The mist of light from whence they take their form
> Hides what they are."

As the same light does not come to all eyes, each person sees his own rainbow, the same flower by different rays. White substances reflect all the light, black substances absorb all but that which renders them visible, while coloured bodies decompose the light, absorb some of the colours, and reflect or transmit the rest. Thus a violet absorbs all but

[1] The reader is referred to the 18th section of the 'Physical Sciences' for reflection, refraction, and absorption of light, and to the 19th section for the constitution of the solar light and colours.

the violet rays, which it reflects; a red flower only reflects the red and absorbs the rest; a yellow substance absorbs all but the yellow. In the same manner transparent substances, whether solid or fluid, absorb some colours and transmit others: thus an emerald absorbs all but the green, a ruby all but the red; whereas a diamond does not decompose the light, but transmits every ray alike. Very few, however, of the colours, whether transmitted or reflected, are pure, but the substance takes its hue from the colour that predominates.

The atmosphere absorbs all the colours of the sun's light except the blue, which is its true colour. In countries where the air is pure, the azure of the sky is deep; it is still more so at great elevations, where the density of the air is less; and its colour is most beautiful as it gradually softens the outlines of the mountains into extreme distance, or blends the sea with the sky. The air reflects and scatters part of the white solar beams, whence the brightness and cheerfulness of day; that property, together with the refractive power of the aqueous vapour, gives the roseate hue to the early morning, and the gold and scarlet tints to the closing day. Were it not for the reflective power of the air, the sun and moon would be like sharply defined balls of fire in the profoundly black vault of the heavens, and dark night would instantly follow sunset. When the sun is 18 degrees below the horizon, the air, at the height of 30 miles, is still dense enough to reflect his rays, and divide the day from the night by the solar shades of twilight.

A considerable portion of the sun's light is absorbed by the atmosphere: the loss increases with the density and obliquity of incidence and the density of the air. It is diminished 1300 times by the thickness of the air in the horizon, which enables us to look at the sun when setting without being dazzled.

Mirage, or the delusive appearance of water, so frequent in deserts, is owing to the reflection of light between two strata of air of different densities, occasioned by the radiation of heat from the arid soil. It is very common on the extensive plains in Asia and Africa, and especially in Upper Egypt; villages on small eminences above the plain appear as if they were built on islands in the middle of a lake when the dry sandy ground is heated by the mid-day sun. Sometimes objects appear double, and occasionally several images appear above one another, some direct and some inverted; this is particularly the case in high latitudes, where the Icy Sea cools the stratum of air resting on it.[1]

In the polar regions, or on the tops of mountains, when the sun is in the horizon the shadow of a person is sometimes thrown on an opposite cloud or mist, the head being surrounded by concentric coloured rings or circles, the number varying from one to five; Captain Scoresby saw four of these rings, on one occasion, round the shadow of his head, as he stood between the sun and a thick low fog: the first ring consisted of concentric bands of white,

[1] For the cause of mirage, see the 'Connexion of the Physical Sciences.'

yellow, red, and purple; the second consisted of concentric bands of blue, green, yellow, red, and purple; the third of green, white, yellowish white, red, and purple; and in the fourth were greenish white, deeper on the edges. These appearances, called *glories*, or fog-images, and the coronæ or small concentric coloured circles which surround the sun or moon when partly obscured by thin white clouds, are owing to the refraction of the light in the aqueous particles of the cloud or fog. The colours in the concentric bands of the coronæ, however, differ from the foregoing; that nearest the sun is of deep blue, white, and red; the circle exterior to that consists of purple, blue, green, pale yellow, and red; but the series is very rarely complete.

Halos, which surround the sun in large circles, or a complicated combination of circles, are, on the contrary, supposed to be produced by the light falling on minute crystals of ice suspended in the atmosphere; they are particularly brilliant and frequent in high latitudes. It is scarcely possible to give an idea of these beautiful and singular objects. Sometimes a large coloured circle surrounds the sun or passes through his centre, which is occasionally touched or cut by segments of others. One seen at St. Petersburg on the 29th of June, 1790, consisted of four coloured circles of different sizes intersecting each other, which were either cut or touched by segments of eight others, and at the points of intersection mock suns or parhelia appeared. The sky is very hazy on these occasions. Mock suns, without

circles and halos, are by no means uncommon round both sun and moon, but seldom of that complicated kind. They are situate between the observer and the sun, whereas the rainbow is always in that part of the sky opposite the sun, because it is produced by refraction and reflection of the sun's rays in the drops of rain; and when the light is intense and the rain abundant, there are two concentric bows, the prismatic colours of the innermost of which are the most vivid, the violet being within and the red outside: sometimes the inner edge exhibits a repetition of colours in fine fringes, in which red and green predominate. The colours are reversed in the exterior bow, the violet being outside and the red on the inner edge. Besides these two principal and most common bows, supernumerary rainbows occasionally appear within the interior bow, generally green and violet, though there are sometimes more or less perfect repetitions of all the colours. In squally weather a rainbow is sometimes seen on a blue sky when rain is falling, but it is generally on clouds; it is constantly seen when the sun shines on the fine drops of fountains and cascades. As the light of the moon is feeble, lunar rainbows are rare, and, for the most part, colourless. In the early morning, when the sun throws his slanting beams across the fields, a miniature bow, with all its vivid colours, may be seen in each dewdrop as it hangs on the points of the bending grass.

Light is said to be polarized when, after having been once refracted or reflected, it is rendered inca-

pable of being again refracted or reflected at certain angles. For example, if a crystal of brown tourmaline be cut longitudinally into thin slices, and polished, the light of a candle may be seen through a slice as if it were glass. But if one of these slices be held perpendicularly between the eye and the candle, and a second slice be turned round between the eye and the other plate of tourmaline, the image of the candle will vanish and come into view at every quarter-revolution of the plate, varying through all degrees of brightness down to total or almost total evanescence, and then increasing again by the same degrees as it had decreased. Thus the light, in passing through the first plate of tourmaline, is said to be polarized because it has been rendered incapable of passing through the second piece of tourmaline in certain positions.

A ray of light acquires the same property if it be reflected from a pane of plate-glass at an angle of 57 degrees; it is by that rendered incapable of being reflected by another pane of plate-glass in certain definite positions, for the image of the light vanishes and reappears alternately at every quarter-revolution of the second pane.

If a thin plate of mica be interposed when the image of the candle has vanished, the darkness will instantly disappear, and a succession of the most gorgeous colours will come into view, varying with every inclination of the mica, from the richest reds to the most vivid greens, blues, and purples. The most splendid colours arranged in symmetrical forms

are exhibited by thin plates of an infinite variety of substances besides mica. They display some of the most beautiful objects in nature, and show differences otherwise inappreciable in the arrangement of the molecules of crystalline bodies.[1]

M. Arago discovered that the light of the sun is polarized by the reflection of the atmosphere, but not equally so on every part of the sky; the polarization is least in the vicinity of the sun, and greatest at 90° from him, for there his light is reflected at an angle of 45°, which is the polarizing angle for air.[2] There are three points in the sky where the light is not polarized: one of these neutral points, discovered by M. Arago, is 18° 30′ above the point diametrically opposite to the sun when he is in the horizon; the second neutral point, discovered by M. Babinet, is 18° 30′ above the sun when he is rising or setting; and the third, discovered by Sir David Brewster, is 15° or 16° below the sun. These points vary with the height of the sun, and the two latter rise and coincide in his centre when he is in the zenith.[3]

Now the portion of polarized light sent to the eye from any part of a clear sky is in a plane passing through that point, the eye of the observer, and the centre of the sun. If that point be the north pole

[1] For phenomena and theory of polarized light, see section 21, 'Connexion of the Physical Sciences.'

[2] Every substance, whether solid or fluid, has its own polarizing angle.

[3] The reader is referred to a plate in Johnston's Physical Atlas showing the phenomena of the polarization of the atmosphere.

of the heavens, it is clear that, as the sun moves in his diurnal course, the plane will move with him as an hour circle, and may be used as a dial to determine the hour of the day. Professor Wheatstone, by whom that beautiful application of the polarization of the atmosphere has been made, has constructed a clock, of very simple form, which shows the time of day with great accuracy, and which has many advantages over a sun-dial.

ELECTRICITY.

Electricity pervades the earth, the air, and all substances, without giving any visible sign of its existence when in a latent state, but, when elicited, it exhibits forces capable of producing the most sudden, violent, and irresistible effects. It is roused from its dormant state by every disturbance in the chemical, mechanical, or calorific condition of matter, and then experience shows that bodies in one electric state repel, and in another they attract each other. Probably their mutual attraction and repulsion arise from the redundancy and defect of electricity; in the first case they are said to be positively, in the latter negatively electric.[1] When they have different kinds of electricity they attract each other, and, when not opposed, the electricity coalesces with great rapidity, producing the flash, explosion, and shock, and that with the more violence the greater the tension or pressure of the electricity on the surrounding air

[1] See sections 28 and 29 of the 'Connexion of the Physical Sciences:' on Electricity.

which resists its escape. Equilibrium is then restored, and the electricity remains latent till called forth by a new exciting cause. The electrical state of substances is easily disturbed, for, without contact, positive electricity tends to produce negative electricity in a body near it, and *vice versâ*: the latter is then said to be electric by induction.

The electricity of the atmosphere arises from evaporation, and the chemical changes that are in perpetual progress on the globe; no electricity, however, is developed by the evaporation of pure water, but it arises abundantly from water containing matter susceptible of chemical action during the evaporation; consequently the ocean is one of the greatest sources of atmospheric electricity; combustion is another, and a large portion arises from vegetation. The air, when pure, is almost always positively electric; but as the chemical changes on the earth sometimes produce positive and sometimes negative electricity, it is subject to great local variations; a passing cloud or a puff of wind produces a change, and a distant storm renders it negative for the time, but the earth is always in a negative state. The quantity of electricity varies with the hours of the day and the seasons; it is more powerful in the day than in the night, in winter than in summer, and it diminishes from the equator to the poles. It thunders daily in many places, in others never, as on the east coast of Peru and in the Arctic regions, except where there are violent volcanic explosions, which always generate electricity, as in Iceland. Wherever there are

no trees or high objects to conduct it to the ground, the quantity of positive electricity increases with the height above the surface of the earth. Violent thunder-storms take place on the tops of the Andes and Himalaya mountains, at heights of 26,650 feet above the plains.

Electricity becomes very strong when dew is deposited, and in some cases it is strongly developed in fogs. Mr. Cross found it so powerful on one occasion, that it was dangerous to approach the apparatus for measuring its intensity. A continued succession of explosions lasted nearly five hours, and the stream of fire between the receiving-ball and the atmospheric conductor was too vivid to look at. M. Peltier has found that the common fogs arising from the mere condensation of the moisture in the air are neutral, but that others, which are produced by exhalations from the earth, are sometimes positive, sometimes negative; the subject, however, requires further investigation.

Though in long-continued mild rains there are no traces of electricity, yet, when rain or snow falls from the higher regions of the atmosphere, it is more or less developed, sometimes positive, sometimes negative, depending a good deal on the direction of the wind. The atmosphere being positively electric, negative rain is supposed to arise from the evaporation of the drops in passing through dry air; the vapour carries off the positive electricity and leaves the drop in a negative state—a circumstance which seems to be confirmed by the electricity of cascades,

near which there always is more or less negative electricity; the positive flows into the earth, while the other remains united to the drops of the cascade.

The inductive action of the earth upon the clouds, and of the different strata of clouds on each other, produces great variations in their electrical state. If rain falls from the lowermost of two strata of positively electrical clouds, the inductive action of the earth renders the under surface positive and the upper negative, and the rain is positive. By-and-bye the under surface of the cloud and the earth become neutral; and after a time the lower cloud becomes charged with negative electricity by the induction of the upper strata, and the rain is then negatively electric. Clouds are very differently charged; grey clouds have negative—red, white, and orange clouds positive electricity; and when clouds differently charged meet, an explosion takes place. When the sky is clear and the air calm and warm, a succession of small white fleecy clouds rising rapidly above the horizon, and flying swiftly in the very high regions of the atmosphere, is a certain presage of a thunder-storm.

Electricity of each kind is probably elicited by the friction of currents of air, or masses of clouds moving rapidly in different directions, as in thunder-storms, when small white clouds are seen flying rapidly over the black mass; yet the quick and irregular motion of clouds in storms is probably owing to the strong electrical attraction and repulsion among themselves, though both may be con-

cerned in these hostile encounters. When two clouds differently charged by the sudden condensation of vapour, and driven by contending winds, approach within a certain distance, the thickness of the coating of electricity increases on the two adjacent sides, and, when the accumulation becomes so great as to overcome the coercive pressure of the atmosphere between them, a discharge takes place which occasions a flash of lightning. The actual quantity of electricity in any part of a cloud is very small. The intensity of the flash depends upon the extent of surface occupied by the electricity, which acquires its intensity by its instantaneous condensation.

The air, being a non-conductor, does not convey the electricity from the clouds to the earth, but it acquires from them an opposite electricity, and when the tension is very great the force of the electricity becomes irresistible, and an interchange takes place between the clouds and the earth, but the motion of the lightning is so rapid that it is difficult to ascertain when it goes from the clouds to the earth, or from the earth to the clouds, though there is no doubt it does both: explosions have burst from the ground, and people have been killed by them.

When the air is highly rarified by heat its coercive power is diminished, so that the electricity escapes from the clouds in the form of diffuse lambent sheets of lightning without thunder or rain, frequently seen in warm summer evenings, sometimes even near the zenith, and quite different from that sheet-lightning at the horizon which is in general only the reflection

of the forked lightning of a distant storm. When the quantity of electricity developed by the sudden condensation of vapour is very great, the lightning is always forked; its zigzag form is occasioned by the unequal conducting power of the air, by which it is sometimes divided into several branches. The author once saw a flash divide into four parallel streams—a very uncommon occurrence. Occasionally in very great storms the lightning sends off lateral branches. It often appears as a globe of fire moving so slowly that it is visible for several seconds, while the flashes of forked lightning do not last the millionth part of a second. Professor Wheatstone, who has measured the velocity of lightning by experiments of great ingenuity, found that it far surpasses the velocity of light, and would encircle the globe in the twinkling of an eye. This inconceivable velocity is beautifully exemplified in the electric telegraph, by which the most violent and terrific agent in nature is rendered obedient to man, and conveys his thoughts as rapidly as they are formed. The colour of lightning is generally a dazzling white or blue, though in highly rarified air it is rose-colour or violet.

The sudden compression of the air during the passage of lightning must convert a great quantity of latent into sensible heat, for heat in a latent or insensible state exists in all bodies independent of their temperature. Heat is absorbed and becomes insensible to the thermometer when solids become liquids, and when liquids are changed to vapour;

and it again becomes sensible when vapour is condensed, and when liquids become solid. When water freezes, all the heat that kept it liquid is given out; and when ice melts, it absorbs heat from everything near it. The air is full of heat in a latent state, whatever its temperature may be, but it can be squeezed out by sudden compression so as to kindle tinder. Every aërial wave, every sound, every word spoken must set free an infinitesimal quantity of heat; so everything that tends to rarify the air must cause it to absorb a proportional quantity.

The rolling noise of thunder is probably owing to the difference between the velocity of lightning and that of sound. Thunder may be regarded as originating in every point of a flash of lightning at the same instant; and as sound takes a considerable time to travel, it will arrive first from the nearest point; and if the flash run in a direct line from a person, the noise will come later and later from the remote points of its path, in a continued roar. Should the direction of the flash be inclined, the succession of sounds will be more rapid and intense; and if the lightning describe a circular course above a person, the sound will arrive at the same instant from every point with a stunning crash.[1]

In passing to the earth, lightning follows the best

[1] Sound travels at the rate of 1120 feet in a second in air at the temperature of 62° of Fahrenheit; so if that number be multiplied by the number of seconds elapsed between the flash of lightning and the thunder, the result will be the distance in feet at which the stroke took place.

conductors—metals by preference, then damp substances—which is the reason why men and animals are so often struck. If it meets with a bad conductor, it shivers it to pieces and scatters the fragments to a considerable distance. A powerful flash scatters gunpowder, while a feeble one ignites it; the hardest trees are split and torn to shreds; when a tree is struck, the heat of the flash converts the sap into steam, the expansive force of which shivers the tree. The surface of rocks is vitrified by it; and when it falls on a sandy soil, its course underground is marked by vitrified tubes many feet long.

Thunder-storms occur daily within the region of the Variables, which is also the region of storms: in countries under the influence of the monsoons they are tremendous at the changes of these periodical winds; where the trade-winds prevail they are hardly known, though electrical discharges are frequent at their limits. In Greece and Italy there are about 40 thunder-storms annually, which occur in spring and autumn, while north of the Alps they chiefly take place in summer. There are about 24 in the year on the coasts of the Atlantic and in Germany, but they are much more frequent among mountains than on plains. In the interior of the old continent they rarely occur in winter, and three-fourths of the number happen in summer. They are of such rare occurrence in high latitudes that in a residence of 6 years in Greenland Sir Charles Geiseke only heard it thunder once.

Some storms arise from the contention of opposite

currents in the air; others are occasioned by currents of warm air ascending from the earth, which are suddenly condensed as they enter the upper regions of the atmosphere, and, as this sometimes happens at the hottest hour of the day, these storms are periodical for many successive days, recurring always at the same hour. Sometimes they extend over a great expanse of country, and the lightning darts from all points of the compass. A person may be killed at the distance of 20 miles from the explosion by the *back stroke*. If the two extremities of a highly charged cloud dip towards the earth, they will repel the electricity of the earth, if it be of the same kind with their own, and will attract the other kind; and if a discharge should take place at one end of the cloud, the equilibrium will instantly be restored by a flash from that part of the earth which is under the other, sufficiently strong to destroy life, and it is the most dangerous, though never so strong as the direct stroke.

When thunder-clouds are very low, there is frequently no lightning; the electricity produced by induction is so powerful that it escapes from pointed objects in the shape of flame without heat, known as St. Elmo's fire. These flames are not unfrequently seen at the topmasts of ships and the extremities of their yard-arms. Bodies between the clouds and earth may be electrized by induction, and their electricity will be seen in the form of flame, as showers of phosphorescent snow.

Phosphorescence is ascribed to electricity; various

substances emit light when decaying, as fish and wood. Although many marine animals are phosphorescent, yet the luminous appearance which the sea often assumes is not always to be attributed to them, but probably to the decaying animal matter it contains.

The aurora is decidedly an electrical phenomenon. It generally appears soon after sunset in the form of a luminous arch stretching more or less from east to west, the most elevated point being always in the magnetic meridian of the place of the observer: across the arch the coruscations are rapid, vivid, and of various colours, darting like lightning to the zenith, and at the same time flitting laterally with incessant velocity. The brightness of the rays varies in an instant: they sometimes surpass the splendour of stars of the first magnitude, and often exhibit colours of admirable transparency, blood-red at the base, emerald-green in the middle, and clear yellow towards their extremity. Sometimes one, and sometimes a quick succession of luminous currents run from one end of the arch or bow to the other, so that the rays rapidly increase in brightness; but it is impossible to say whether the coruscations themselves are actually affected by a horizontal motion of translation, or whether the more vivid light is conveyed from ray to ray. The rays occasionally dart far past the zenith, vanish, suddenly reappear, and, being joined by others from the arch, form a magnificent corona or immense dome of light. The segment of the sky below the arch is quite black,

as if formed by dense clouds; yet M. Struve is said to have seen stars in it, consequently the blackness must be from contrast. The lower edge of the arch is evenly defined; its upper margin is fringed by the coruscations, their convergence towards the north, and that of the arch itself, being probably an effect of perspective.

Either the aurora must be high above the earth, or its coruscations must be very extensive, since the same display is visible at places wide asunder. It has frequently been seen in North America and all over the north of Europe at the same time, sometimes even as far south as Italy, yet Sir Edward Parry certainly saw a ray dart from it to the ground near him. M. Struve, Admiral Wrangel, and others who have had many opportunities of seeing the aurora in high latitudes, assign a very moderate elevation to it. The arch probably passes through the magnetic pole; hence in the north of Greenland it lies south of the observer, and Sir Edward Parry saw it to the south in Melville Island, which is in 70° N. lat.; consequently it must appear in the zenith in some places. Dr. Faraday conjectures that the electric equilibrium of the earth is restored by the aurora conveying the electricity from the poles to the equator, for it appears in the high southern latitudes, as well as in the northern; and the Rev. G. Fisher has lately suggested, that, as the principal display of the aurora takes place at or near the margin of the polar ice, the electricity may be conveyed by the conducting power of the frozen

particles which abound in the air in these latitudes, and which, being rendered fitfully luminous by the passage of the electricity, produce the arch and the ever-varying flashes of the aurora.

The aurora has a powerful influence on the magnetic needle, even in places where the display is not seen. Its vibrations seem to be slower or quicker according as the auroral light is quiescent or in motion, and the disturbances of the compass during the day show that the aurora is not peculiar to the night. Observations have proved that the disturbances of the magnetic needle and the auroral displays were simultaneous at Toronto, in Canada, on 13 days out of 24, the remaining days having been clouded; and contemporaneous observations show that on these 13 days there were also magnetic disturbances at Prague and at Van Diemen's Land, so that the "occurrence of aurora at Toronto on these occasions may be viewed as a local manifestation connected with magnetic effects, which, whatever may have been their origin, probably prevailed on the same day over the whole surface of the globe." [1]

MAGNETISM.

Magnetism is one of those unseen imponderable existences which, like electricity and heat, are known only by their effects. It is certainly identical with electricity, for, although it never comes naturally

[1] Colonel Sabine's Notes to 'Kosmos.'

into evidence, magnets can be made to exhibit all the phenomena of electrical machines.

Terrestrial magnetism, which pervades the whole earth, is extremely complicated; it varies both with regard to space and time, and, probably, depends upon the heat of the sun, upon his motion in the ecliptic, which produces changes of temperature, on galvanic currents circulating through the surface of the globe, and possibly on the earth's rotatory motion.

The distribution of terrestrial magnetism is determined by the declination-needle, or mariner's compass, and the dipping-needle; they consist of magnetised needles or bars of steel, so suspended that the declination-needle revolves in a horizontal direction, and the dipping-needle moves in a plane perpendicular to the horizon. The north end of the declination-needle or magnet points to the north, and the south end to the south, and it only remains at rest when in that position. The direction of the needle is the magnetic meridian of the place of observation.

The north end of the dipping-needle bends or dips below the horizon in the northern hemisphere, and the south end bends or dips beneath it in the southern hemisphere, and between the two there is a line which encircles the whole earth, where the dipping-needle remains horizontal. That line, which is the magnetic equator or line of no dip, crosses the terrestrial equator in several places, extending alternately on each side, but never deviating more than 12 degrees from it. The deviation is

greater in that part of the Pacific where there are most islands, and it is greatest both to the south and north in traversing the continents of Africa and America; thus it appears that the configuration of the land and water has an influence on terrestrial magnetism. North and south of the magnetic equator the needle dips more and more, till at last it becomes perpendicular to the horizon in two points, or rather linear spaces, known as the north and south magnetic poles, which are quite distinct from the poles of the earth's rotation. One, whose position was determined by Captain Ross, is in 70° N. lat. and 97° W. long., while that in the southern hemisphere, determined by Sir James Ross, in the interior of Victoria Island, is in 70° S. lat. and 162° E. long. Lines of equal dip are such as may be drawn on a globe through all those places where the dipping-needle makes the same angle with the horizon. The angle of the dip is not always the same: according to Colonel Sabine, who is the highest authority on this subject, it has been decreasing in the northern hemisphere, for the last fifty years, at the rate of three minutes annually: it is also subject to variations of short periods, and it seems to be affected by shocks of earthquakes, even when very distant.

The intensity of the magnetic force is as variable and even more complicated than the other magnetic phenomena: it is measured by the number of vibrations made by the declination-needle in a given time. It is very different in different parts of the

earth, but there are four points in which the intensity is greater than anywhere else. Two of these are in the northern and two in the southern hemisphere; they neither coincide with the poles of the earth's rotation nor with the magnetic poles, nor are they all of equal intensity.

One of these foci of maximum magnetic intensity is situate in North America, south-west from Hudson's Bay; another is in northern Siberia in 120° E. long. In the southern hemisphere, one of the points of maximum magnetic intensity is in the South Atlantic in 20° S. lat. and 324° E. long., and the other is situate in 60° S. lat. and 131° 20′ E. long.[1] In consequence of the unequal intensity of the force in these 4 foci, the decrease in magnetic power from them towards the equator is extremely irregular, so that the dynamic equator, which is a line supposed to be drawn through all the points on the earth where the intensity is the least, encircles the globe in a waving line, which neither coincides with the geographical nor magnetic equator; it forms the division between the magnetic intensities in the two hemispheres. Lines drawn

[1] The foci are all of different intensities; that in the South Atlantic, discovered by M. Erman, has the least intensity of the four, and the other in the southern hemisphere, discovered by Sir James Ross, has the greatest; taking 1 as the unit at the magnetic equator in Peru, their intensities are as 2·071 and 0·706. In the northern hemisphere the American focus is more intense than that in Siberia, which is moving from west to east, while the minor focus in the southern hemisphere is moving from east to west.

on a globe through all the points where the magnetic intensity is the same are so complicated that it is scarcely possible to convey an idea of them in words. They form a series of ovals round each of the foci of maximum force, then a figure of 8 in each hemisphere having a focus and its ovals in each loop, then they open into tortuous lines which encompass the globe, but which become less so as they approach the dynamic equator. The complication is increased by the foci in the two hemispheres being unsymmetrically placed with regard to one another, as well as by the difference in their intensities.

The declination or horizontal needle only remains at rest when in a magnetic meridian, that is, when it points to the north and south magnetic poles. The magnetic meridians coincide with the geographical meridians in some places, and in these the magnet points to the true north and south, that is, to the poles of the earth's rotation. But if it be carried successively to different longitudes, it will deviate sometimes to the east, sometimes to the west of the true north. Imaginary lines on the globe, passing through all places where the magnet points to the poles of the earth's rotation, are lines of no variation; and lines passing through all places where the magnet deviates by an equal quantity from the geographical meridians are lines of equal variation; they are also very irregular and form two closed systems or loops,—that is, they surround two points, one in northern Siberia and another in the Pacific,

nearly in the meridian of the Pitcairn Islands and the Marquesas.[1]

The whole magnetic system is perpetually undergoing secular and periodical changes, which are so irregular and complicated that half a century is sufficient to alter the form and position of all the lines that have been mentioned. The foci of magnetic intensity, and the whole system represented by the magnetic lines, are moving along the two hemispheres in opposite directions; those in the northern hemisphere are going from west to east, and those in the southern from east to west; and as the foci of maximum intensity move with different velocities, the forms, as well as the places, of the curves are slowly, yet continually, changing. The weaker magnetic focus in the northern hemisphere moved through 50 degrees of longitude in 250 years.

The declination is subject to periodic variations depending upon the position of the moon, and to annual variations arising from the motion of the sun in the ecliptic, as well as to horary variations corresponding to changes of temperature from the diurnal rotation of the earth.

Throughout the middle latitudes of the northern hemisphere the north end of the magnet has a mean

[1] The author is indebted to the admirable and profound investigations of Colonel Sabine for almost all she knows on the subject of terrestrial magnetism. In these, and in his notes on the English translation of 'Kosmos,' the reader will find all that is most interesting on the subject. In his own works there are plates of the course of the different magnetic lines mentioned in the text.

motion from east to west from eight in the morning till half-past one, it then moves to the east till evening, after which it makes another excursion to the west, and returns again to its original position at eight in the morning. The extent of its variation is greater in the day than in the night, in summer than in winter. It decreases from the middle latitudes in Europe, where it is 13 or 14 minutes, to the equator, where it is only 3 or 4; but at the equator the variations are performed with extreme regularity. The horary motions of the south end of the magnet in the southern hemisphere are accomplished in an exactly opposite direction. Between these two magnetic hemispheres there is a line passing through an infinity of places, and very nearly coinciding with the line of minimum magnetic intensity, where the horary phenomena of both hemispheres are combined, each predominating alternately at opposite seasons. At St. Helena, which is one of the places in question and nearly on the line of minimum intensity, the horary motion of the north end of the magnet corresponds in direction during one half of the year with the movement in the northern hemisphere, and in the other half of the year the direction at the same hours corresponds with that in the southern hemisphere, the passage from the one to the other being at the equinoxes, when the diurnal variations at the usual hours partake more or less of the characteristics of both on different days.[1]

[1] At St. Helena the north end of the needle reaches its eastern extreme in May, June, July, and August, and nearly

It thus appears that there are six points on the earth peculiarly remarkable for magnetic phenomena, all of which are distinct from one another, and from the poles of the earth's rotation—namely, two magnetic poles where the dipping-needle makes an angle of 90 degrees with the horizon. The magnetic equator corresponds with these in every point of which the angle of the dip is zero: it encircles the earth, and intersects the terrestrial equator, but does not coincide with it. The other four points are the foci of maximum magnetic intensity, and to them the dynamical equator or line of minimum magnetic intensity corresponds, also surrounding the earth in an irregular line, but which coincides with neither the terrestrial nor magnetic equator. Besides these, and either partly or nearly coinciding with the line of minimum intensity, is that line which is supposed to pass through all places where the horary variations of the magnet partake of the phenomena of each hemisphere alternately.

The earth's magnetism is subject to vast unaccountable commotions or storms of immense extent, which occur at irregular intervals and are of short duration. In 1818 a magnetic storm, shown by a violent agitation of the needle, took place at the

at the same hours it reaches its western extreme in November, December, January, and February. The passage from one to the other takes place at, or soon after, the equinoxes in March and April, September and October.—Colonel Sabine's Notes to 'Kosmos.'

same time over 47 degrees of longitude, extending through all the countries from Paris to Kasan; and on the 25th of September, 1841, one of these storms was simultaneously observed at Toronto in North America, at the Cape of Good Hope, Prague in Europe, at Macao in China, and there is reason to believe that it extended to Van Diemen's Land. Similar storms have happened simultaneously in Sicily and at Upsala in Sweden; others of less extent and shorter periods more frequently occur, and are, like the greater storms, not to be attributed to any known cause.

M. Necker de Saussure has traced a marked coincidence between the prevailing direction of the stratified masses of the mountain chains and that of the curves of equal magnetic intensity. The coincidence is perfect in the Ural chain, for there the lines of force tend north and south; and they do not deviate much from the stratification in the great plains of European Russia. There is every reason to believe that a coincidence takes place in the Scandinavian mountains, for a line of equal magnetic intensity passes parallel to the Norwegian coast. In Scotland a line almost coincides with the Grampians; and as it becomes less northerly before reaching Portugal and Spain, it is there also in singular coincidence with the sierras on the table-land; the Pyrenees however form an exception to the law. A magnetic line follows the break of the chain of the Alps with great precision. The intersection of two upheavels makes these mountains

alter their direction from S.W. and N.E. to E. nearly, and near to that change the magnetic line takes a similar bend and coincides with the Caucasus, Taurus, Hindoo-Coosh, Himalaya, and Chinese mountains, after which it again tends to the north, and follows the Yablonoi chain to Behring's Straits.

In Africa the lines of equal magnetic force coincide with the Komri, and with the lofty sea-coast range which unites the mountains of Abyssinia with those at the Cape of Good Hope. Throughout North America the lines of equal force coincide with the Alleghannies, and on the coast of the Pacific they take the direction of the Rocky Mountains. In Mexico the stratified rocks are parallel to the mountains of Anahuac, which is the same with the direction of the magnetic curves, and a similar coincidence takes place in the Parima ranges, and in the coast-chain of Venezuela. The Andes and the lines of equal magnetic intensity are completely discordant, for they cross one another; but lines of equal magnetic force stretch from the southern promontories of America and Asia to the mountains of Victoria Land.

There is strong presumptive evidence of the influence of the electric and magnetic currents on the formation and direction of the mountain masses and mineral veins, but their slow persevering action on the ultimate atoms of matter has been placed beyond doubt by the formation of rubies and other gems, as well as various other mineral substances, by voltaic electricity.

The existence of electric currents on the surface of the earth has been deduced from terrestrial magnetism, and from the connexion between the diurnal variations of the magnet and the apparent motion of the sun; also from the electro-magnetic properties of metalliferous veins, and from atmospheric electricity, which is continually passing between the air and the earth.

Dr. Faraday's brilliant discoveries have changed the received opinions with regard to the magnetic properties of matter. Although all bodies are magnetic, they show that it assumes a totally different form in different substances. For example, if a bar of iron be freely suspended between the poles of an electro-magnet, or very powerful horseshoe magnet, it will be attracted by both poles, and will rest in the direction between them—that is, on the line of force. But if a bar of bismuth be suspended in the same manner, it will be repelled by both poles, and will assume a direction at right angles to that which the iron took, and thus the same force, whether electric or magnetic, produces opposite effects upon these two metals. Substances affected after the manner of iron are magnetic—those affected after the manner of bismuth are said to be *diamagnetic*. All substances come under one or other of these two classes: the diamagnetic are infinitely more abundant than the magnetic; almost all bodies on earth belong to that class. Many of the metals, acids, oils, sugar, starch, animal matter, flame, and all the gases, whether light or heavy,

have the diamagnetic property less or more, but oxygen less than any other, and that is the reason why atmospheric air is the most feebly diamagnetic of all substances at its natural temperature; for when very hot it becomes more diamagnetic, and if extremely cold it takes a place among the magnetic class. Important results with regard to the magnetic state of the globe will undoubtedly be deduced from this new property of matter, and Dr. Faraday's observations on that subject show that he is not without such anticipations.

"When we consider the magnetic condition of the earth as a whole, without reference to its possible relation to the sun, and reflect upon the enormous amount of diamagnetic matter which forms its crust; and when we remember that magnetic curves of a certain amount of force, universal in their presence, are passing through these matters, and keeping them constantly in a state of tension, and therefore of action, we cannot doubt that some great purpose, of utility to the system and to us its inhabitants, is fulfilled by it. If the sun have anything to do with the magnetism of the globe, then it is possible that part of this effect may be due to the action of the light that comes to us from that body; and in that view the air seems most strikingly placed round our sphere, investing it with a transparent diamagnetic, which therefore is permeable to his rays, and at the same time moving with great velocity across them. Such conditions seem to suggest the possibility of magnetism being thence generated."

CHAPTER XXIII.

Vegetation — Nourishment and Growth of Plants — Effects of the different Rays of the Solar Spectrum — Classes — Botanical Districts.

In the present state of the globe a third part only of its surface is occupied by land, and probably not more than a fourth part of that is inhabited by man, but animals and vegetables have a wider range. The greater part of the land is clothed with vegetation and inhabited by quadrupeds, the air is peopled with birds and insects, and the sea teems with living creatures and plants. These organised beings are not scattered promiscuously, but all classes of them have been originally placed in regions suited to their respective wants. Many animals and plants are indigenous only in determinate spots, while a thousand others might have supported them as well, and to many of which they have been transported by man.

Plants extract inorganic substances from the ground which are indispensable to bring them to maturity, but the atmosphere supplies the vegetable creation with the principal part of its food.

The black or brown mould which is so abundant is the produce of decayed vegetables. When the autumnal leaves, the spoil of the summer, fall to the ground, and their vitality is gone, they enter

into combination with the oxygen of the atmosphere and convert it into an equal volume of carbonic acid gas, which consequently exists abundantly in every good soil, and is the most important part of the food of vegetables. This process is slow, and stops as soon as the air in the soil is exhausted; but the plough, by loosening the earth, and permitting the atmosphere to enter more freely and penetrate deeper into the ground, accelerates the decomposition of the vegetable matter, and consequently the formation of carbonic acid.

In loosening and refining the mould, the common earth-worm is the fellow-labourer with man; it eats earth, and, after extracting the nutritious part, ejects the refuse, which is the finest soil and may be seen lying in heaps at the mouth of its burrow. So instrumental is this creature in preparing the ground, that it is said there is not a particle of the finer vegetable mould that has not passed through the intestines of a worm: thus the most feeble of living things is employed by Providence to accomplish the most important ends.

The food of the vegetable creation consists of carbon, hydrogen, nitrogen, and oxygen—all of which plants obtain entirely from the atmosphere in the form of carbonic acid gas, water, and ammonia. They imbibe these three substances, and, after having decomposed them, they give the oxygen to the air, and consolidate the carbon, water, and nitrogen into wood, leaves, flowers, and fruit.

The vitality of plants is a chemical process en-

tirely due to the sun's light; it is most active in clear sunshine, feeble in the shade, and nearly suspended in the night, when plants, like animals, have their rest.

The atmosphere contains only one two-thousandth part of carbonic acid gas, yet that small quantity yields enough of carbon to form the solid mass of all the magnificent forests and herbs that clothe the face of the earth, and the supply of that necessary ingredient in the composition of the atmosphere is maintained by the breath of animals, by volcanos, and by combustion. The green parts of plants constantly imbibe carbonic acid in the day; they decompose it, assimilate the carbon, and return the oxygen pure to the atmosphere. As the chemical action is feeble in the shade and in gloomy weather, only a part of the carbonic acid is decomposed, then both oxygen and carbonic acid are given out by the leaves; but during the darkness of the night a chemical action of a different character takes place, and almost all the carbonic acid is returned unchanged to the atmosphere, together with the moisture which is evaporated from the leaves both night and day. Thus plants give out pure oxygen during the day, and carbonic acid and water during the night.

Since the vivifying action of the sun brings about all these changes, a superabundance of oxygen is exhaled by the tropical vegetation in a clear unclouded sky, where the sun's rays are most energetic, and atmospheric moisture most abundant. In the

middle and higher latitudes, on the contrary, under a more feeble sun and a gloomy sky, subject to rain, snow, and frequent atmospheric changes, carbonic acid is given out in greater quantity by the less vigorous vegetation. But here, as with regard to heat and moisture, equilibrium is restored by the winds; the tropical currents carry the excess of oxygen along the upper strata of the atmosphere to higher latitudes, to give breath and heat to men and animals; while the polar currents, rushing along the ground, convey the surplus carbonic acid to feed the tropical forests and jungles. Harmony exists between the animal and vegetable creations; animals consume the oxygen of the atmosphere, which is restored by the exhalation of plants, while plants consume the carbonic acid exhaled by men and animals; the existence of each is thus due to their reciprocal dependence. Few of the great cosmical phenomena have only one end to fulfil, they are the ministers of the manifold designs of Providence.

When a seed is thrown into the ground, the vital principle is developed by heat and moisture, and part of the substance of the seed is formed into roots, which suck up water mixed with carbonic acid from the soil, decompose it, and consolidate the carbon. In this stage of their growth, plants derive their whole sustenance from the ground. As soon, however, as the sugar and mucilage of the seed appear above the ground, in the form of leaves or shoots, they absorb and decompose the carbonic acid of the atmosphere, retain the carbon for their

food, give out the oxygen in the day, and pure carbonic acid in the night. In proportion as plants grow, they derive more of their food from the air and less from the soil, till their fruit is ripened, and then the whole of their nourishment is derived from the atmosphere. Trees are fed from the air after their fruit is ripe till their leaves fall, annuals till they die. Air-plants and several species of cactus and others derive all their food from the atmosphere. It is wonderful that so small a quantity of carbonic acid as exists in the air should suffice to supply the whole vegetation of the world—and still more wonderful that a seed minute enough to be wafted invisibly by a breath of air should be the theatre of all the chemical changes that make it germinate.[1]

Plants absorb water from the ground by their roots; they decompose it, and the hydrogen combines in different proportions with their carbonic acid to form wood, sugar, starch, gum, vegetable, oils and acids. As the green parts combine with the oxygen of the air, especially during night, when the functions of plants are torpid, it is assimilated on the return of daylight, and assists in forming oils, resins, and acids. The combination of the oxygen of the air with the leaves, and also with the blossom and fruit, during night, is quite unconnected with the vital process, as it is the same in dead

[1] The sporules or seeds of the fungi are so minute that M. Freis counted above ten millions in a single plant of the reticularia maxima: they were so subtile that they were like smoke.

plants. An acid exists in the juice of every plant, generally in combination with an alkali. It must be observed, however, that these different substances are produced at different stages in the growth; for example, starch is formed in the roots, wood, stalk, and seed, but it is converted into sugar as the fruit ripens, and the more starch the sweeter the fruit becomes. Most of these new compounds are formed between the flowering of the plant and the ripening of the fruit, and indeed they furnish the materials for the flowers, fruit, and seed.

Ammonia, the third organic constituent of plants, is the last residue from the decay and putrefaction of animal matter. It is volatilized, and rises into the atmosphere, where it exists as a gas, but in so small a quantity that it is with difficulty detected by chemical analysis; yet, as it is very soluble in water, enough is brought to the ground by rain to supply the vegetable world. Ammonia enters plants by their roots along with rain-water, and is resolved within them into its constituent elements, hydrogen and nitrogen. The hydrogen aids in forming the wood, acids, and other substances before mentioned; while the nitrogen enters into every part of the plant and forms new compounds; it exists in the blossom and fruit before it is ripe, and in the wood, as albumen; it also forms gluten, which is the nutritious part of wheat, barley, oats, and all other cerealia, as well as of esculent roots, as potatoes, beet-root, &c. Nitrogen exists abundantly in peas, beans, and pulse of every kind; it enters into the composition of most elementary

vegetable substances; in short, a plant may grow without ammonia, but it cannot produce seed or fruit; the use of animal manure is to supply plants with this essential article of their food. Thus the decomposition and consolidation of the elementary food of plants, the formation of the green parts, the exhalation of moisture by their leaves, its absorption by their roots, and all the other circumstances of vegetable life, are owing to the illuminating power of the sun. Heat can be supplied artificially in our northern climates, but it is impossible to replace the splendour of a southern sun. His illuminating influence is displayed in a remarkable degree by the cacalia ficoides; its leaves combine with the oxygen of the atmosphere during the night, and are as sour as sorrel in the morning; as the sun rises they gradually lose their oxygen, and are tasteless at noon; by the continued action of light they lose more and more, till towards evening they become bitter. The difference of a clear or cloudy sky has an immense effect on vegetation; the ripening of fruit depends upon the habitual serenity of the sky more than on summer temperature alone.

The blue rays of the solar spectrum have most effect on the germination of seed; the yellow rays, which are the most luminous, on the growing plant. That is on account of the chemical rays, now so well known by their action in Daguerreotype impressions. They are most abundant beyond the visible part of the solar spectrum, and diminish through the violet, blue, and green, to the yellow, where they cease.

They penetrate the ground, and have a much greater influence on the germination of seeds than ordinary light or darkness. That invisible principle, together with light, is essential to the formation of the colouring matter of leaves; it is most active in spring, and is in very considerable excess compared with the quantity of light and heat; but as summer advances the reverse takes place; the calorific radiation, or those hot rays corresponding to the extreme red of the spectrum, which facilitate the flowering and forming of the fruit, become by far the most abundant; and a set of invisible rays, which exist near the point of maximum heat in the solar spectrum, are also most abundant in summer. Mr. Hunt found that the hot rays immediately beyond the visible red destroy the colour of palm-leaves; and for that reason the glass of the palm-house at Kew Gardens is tinged pale yellow-green by oxide of copper, which excludes the scorching rays in question, though it is permeable by the other rays of heat, those of light, and the chemical rays.[1]

[1] The solar spectrum, or coloured image of the sun, formed by passing a sunbeam through a prism, is composed of a variety of invisible as well as visible rays. The chemical rays are most abundant beyond the violet end of the spectrum, and decrease through the violet, blue, and green, to the yellow, where they cease. The rays of heat are in excess a little beyond the red end, and gradually decrease towards the violet end. Besides these there are two insulated spots at a considerable distance from the red, where the heat is a maximum. Were the rays of heat visible, they would exhibit differences as distinct as the coloured rays, so varied are their properties according to their position in the spectrum. There are also

In spring and summer the oxygen taken in by the green leaves in the night aids in the formation of oils, acids, and the other parts that contain it; but as soon as autumn comes, the vitality or chemical action of vegetables is weakened; and the oxygen, no longer given out in the day, though still taken in during the night, becomes a minister of destruction; it changes the colour of the leaves, and consumes them when they fall. Nitrogen, so essential during the life of plants, also resumes its chemical character when they die, and by its escape hastens their decay.

Although the food which constitutes the mass of plants is derived principally from water and the gases of the atmosphere, fixed substances are also requisite for their growth and perfection, and these they obtain from the earth by their roots. The inorganic matters are the alkalis, phosphates, silica, sulphur, iron, and others.

It has already been mentioned that vegetable acids are found in the juices of all the families of plants. They generally are in combination with one or other of the alkaline substances, as lime, soda, potash, and magnesia, which are as essential to the existence of plants as the carbonic acid by which these acids are formed: for example, vines have potash; plants used

peculiar rays which produce phosphorescence, others whose properties are not quite made out, and probably many undiscovered influences; for time has not yet fully revealed the sublimity of that creation, when God said, "Let there be light—and there was light."

as dyes never give vivid colours without it; all leguminous plants require it, and only grow naturally on ground that contains it. None of the corn tribe can produce perfect seeds unless they have both potash and phosphate of magnesia: nor can they or any of the grasses thrive without silica, which gives the hard coating to straw, to the beard of wheat and barley, to grass, canes, and bamboos; it is even found in solid lumps in the hollows and joints of cane, known in India by the name of tabashir. To bring the cerealia to perfection, it is indispensable that in their growth they should be supplied with carbonic acid for the plant, silica to give it strength and firmness, and nitrogen for the grain.

Phosphoric acid, combined with an earth or alkali, is found in the ashes of all vegetables, and is essential to many. Pulse contain but little of it, and on that account are less nutritious than the cerealia. The family of the cruciferæ, as cabbages, turnips, mustard, &c., contain sulphur in addition to the substances common to the growth of all plants; each particular tribe has its own peculiarities, and requires a combination suited to it. On that account there is often a marked difference in the arborescent vegetation on the same mountain, depending on the nature of the rocks.

The ocean furnishes some of the matters found in plants; the prodigious quantity of sea-water constantly evaporated carries with it salt in a volatilized state, which, dispersed over the land by the wind, supplies the ground with salt and the other ingre-

dients of sea-water. The inorganic matters which enter plants by their roots are carried by the sap to every part of the vegetable system. The roots imbibe all liquids presented to them indiscriminately, but they retain only the substances they require at the various stages of their growth, and throw out such parts as are useless, together with the effete or dead matter remaining after the nutriment has been extracted from it. Plants, like animals, may be poisoned, but the power they have of expelling deleterious substances by their roots generally restores them to health. The feculent matter injures the soil; besides, after a time the ground is drained of the inorganic matter requisite for any one kind of plant: hence the necessity for a change or rotation of crops.

A quantity of heat is set free and also becomes latent in the various transmutations that take place in the interior of plants; so that they, like the animal creation, have a tendency to a temperature of their own, independent of external circumstances.

The quantity of electricity requisite to resolve a grain weight of water into its elementary oxygen and hydrogen is equal to the quantity of atmospheric electricity which is active in a very powerful thunder-storm; hence some idea may be formed of the intense energy exerted by the vegetable creation in the decomposition of the vast mass of water and other matters necessary for its sustenance. But there must be a compensation in the consolidation of the vegetable food, otherwise a tremendous quantity would

be in perpetual activity. It is said to be given out from the points of their leaves, so possibly some part of the atmospheric electricity may be ascribed to this cause; but there is reason to believe that electricity, excited by the power of solar light, constitutes the chemical vitality of vegetation.

The colouring matter of flowers is various, if we may judge from the effect which the solar spectrum has upon their expressed juices. The colour is very brilliant on the tops of mountains and in the Arctic lands. Possibly the diminished weight of the air may have some effect, for it can scarcely be supposed that barometrical changes should be entirely without influence on vegetation.

The perfume of flowers and leaves is owing to a volatile oil, which is often carried by the air to a great distance: in hot climates it is most powerful in the morning and evening. The odour of the Humiria has been perceived at the distance of three miles from the coast of South America, a species of Tetracera sends its perfume as far from the island of Cuba, and the aroma of the Spice Islands is wafted out to sea. The variety of perfumes is infinite, and shows the innumerable combinations of which a few simple substances are capable, and the extreme minuteness of the particles of matter.

In northern and mean latitudes winter is a time of complete rest to the vegetable world, and in tropical climates the vigour of vegetation is suspended during the dry, hot season, to be resumed at the return of the periodical rains. The periodical phe-

nomena of the appearance of the first leaves, the flowering, ripening of the fruit, and the fall of the leaf, depend upon the annual and diurnal changes of temperature, moisture, electricity, and perhaps on magnetism, and succeed with such perfect harmony and regularity, that, were there a sufficient number of observations, lines might be drawn on a globe passing through all places where the leaves of certain plants appear simultaneously, and also for the other principal phases of vegetation. In places where the same plant flowers on the same day, the fruit may not ripen at the same period in both; it would therefore be interesting to know what relation lines passing through those would have to one another and to the isothermal lines; more especially with regard to the plants indispensable to man, since the periodicity of vegetation affects his whole social condition.[1]

Almost all plants sleep during the night; some show it in their leaves, others in their blossom. The Mimosa tribe not only close their leaves at night, but their foot-stalks droop; in a clover-field not a leaf opens until after sunrise. The common daisy is a familiar instance of a sleeping flower; it shuts up its blossom in the evening, and opens its white and

[1] Professor Quetelet is desirous that the periodical phenomena of vegetation should be observed at a number of places, in order to establish a comparison between the periods at which they take place; and for that purpose he gives a list of the commonest plants, as lilac, laburnum, elder, birch, oak, horse-chestnut, peach, pear, crocus, daisy, &c., which he himself observes annually at Brussels.

crimson-tipped star, the "day's eye," to meet the early beams of the morning sun; and then also "winking mary-buds begin to ope their golden eyes." The crocus, tulip, convolvulus, and many others, close their blossoms at different hours towards evening, some to open them again, others never. The ivy-leaved lettuce opens at eight in the morning, and closes for ever at four in the afternoon. Some plants seem to be wide awake all night, and to give out their perfume then only, or at nightfall. Many of the jessamines are most fragrant during the twilight: the Olea fragrans, the Daphne odorata, and the night-stock reserve their sweetness for the midnight hour, and the night-flowering Cereus turns night into day. It begins to expand its magnificent sweet-scented blossom in the twilight, it is full blown at midnight, and closes, never to open again, with the dawn of day;—these are "the bats and owls of the vegetable kingdom." [1]

Many plants brought from warm to temperate climates have become habituated to their new situation, and flourish, as if they were natives of the soil; such as have been accustomed to flower and rest at particular seasons change their habits by degrees, and adapt themselves to the seasons of the country

[1] Dandelion opens at five or six in the morning, and shuts at nine in the evening; the goat's-beard wakes at three in the morning, and shuts at five or six in the afternoon. The orange-coloured Escholtzia is so sensitive that it closes during the passage of a cloud. "The marigold that goes to bed wi' the sun, and with him rises weeping," with many more, are instances of the sleep of plants.

that has adopted them. It is much more difficult to transfer alpine plants to the plains. Whether from a change of atmospheric pressure or mean temperature, all attempts to cultivate them at a lower level generally fail: it is much easier to accustom a plant of the plains to a higher situation.

Plants are propagated by seeds, offsets, cuttings, and buds; hence they, but more especially trees, have myriads of seats of life, a congeries of vital systems acting in concert, but independently of each other, every one of which might become a new plant. In this respect the fir and pine tribe are inferior to deciduous trees, which lose their leaves annually, because they are not easily propagated except by seeds. It has been remarked that all plants that are propagated by buds from a common parent stock have the same duration of life: this has been noticed particularly with regard to some species of apple-trees in England. It appears that all the garden varieties of fruit, whether from buds, layers, or cuttings, wear out after a time; and that seedlings have a great tendency to revert to the original wild character of the plant.

A certain series of transitions takes place throughout the lives of plants, each part being transformed and passing into another; a law that was first observed by the illustrious poet Göthe. For example, the embryo leaves pass into common leaves, these into bracteæ, the bracteæ into sepals, the sepals into petals, which are transformed into stamens and anthers, and these again pass into ovaries with their

styles and stigmas, that are to become the fruit and ultimately the seed of a new plant.

Plants are naturally divided into three classes, differing materially in organization :—The Cryptogamia, whose flowers and seeds are either too minute to be easily visible, or are hidden in some part of the plant, as in fungi, mosses, ferns, and lichens, which are of the least perfect organization. Next to these are the monocotyledonous plants, as grasses and palms, in which the foot-stalks of the old leaves form the outside of the stem ; plants of this class have but one seed-lobe, which forms one little leaf in their embryo state. Their flowers and fruit are generally referable to some law in which the number 3 prevails, as, for example, the petals and other parts are three in number. The dicotyledonous plants form the third class, which is the most perfect in its organization and by much the most numerous, including the trees of the forest and most of the flowering shrubs and herbs. They increase by coatings from without, as trees, where the growth of each year forms a concentric circle of wood round the pith or centre of the stem : the seeds of these plants have two lobes, which in their embryo state appear first in two little leaves above ground, like most of the European species. The parts of the flowers and fruit of this class generally have some relation to the number 5.

The three botanical classes are distributed in very different proportions in different zones : monocotyledonous plants, such as grasses and palms, are much

more rare than the dicotyledonous class. Between the tropics there are four of the latter to one of the grass or palm tribes, in the temperate zones six to one, and in the polar regions only two to one, because mosses and lichens are most abundant in the high latitudes, where dicotyledonous plants are comparatively rare. In the temperate zones one-sixth of the plants are annuals, omitting the cryptogamia; in the torrid zone scarcely one plant in twenty is annual, and in the polar regions only one in thirty. The number of ligneous vegetables increases on approaching the equator, yet in North America there are 120 different species of forest-trees, whereas in the same latitudes in Europe there are only 34. The social plants, grasses, heaths, furze, broom, daisies, &c., which cover large tracts, are rare between the tropics, except on the mountains and table-lands and on the llanos of equatorial America.

Equinoctial America has a more extensive and richer vegetation than any other part of the world; Europe has not above half the number of indigenous species of plants; Asia, with its islands, has somewhat less than Europe; Australia, with its islands in the Pacific, still less; and there are fewer vegetable productions in Africa than in any part of the globe of the same extent.

Since the constitution of the atmosphere is very much the same everywhere, vegetation depends principally on the sun's light, moisture, and the mean annual temperature, and it is also in some degree regulated by the heat of summer in the temperate

zones, and also by exposure, for such plants as require warmth are found at a lower level on the north than on the south side of a mountain. Between the tropics, wherever rain does not fall, the soil is burnt up and is as unfruitful as that exposed to the utmost rigour of frost; but where moisture is combined with heat and light, the luxuriance of the vegetation is beyond description. The abundance and violence of the periodical rains combine with the intense light and heat to render the tropical forests and jungles almost impervious from the rankness of the vegetation. This exuberance gradually decreases with the distance from the equator; it also diminishes progressively as the height above the level of the sea increases, so that each height has a corresponding parallel of latitude where the climates and floras are similar, till the perpetual snow on the mountain-tops, and its counterpart in the polar regions, have a vegetation that scarcely rises above the surface of the ground. Hence, in ascending the Himalaya or Andes from the luxuriant plains of the Ganges or Amazons, changes take place in the vegetation analogous to what a traveller would meet with in a journey from the equator to the poles. This law of decrease, though perfectly regular over a wide extent, is perpetually interfered with by local climate and soil. From the combination of various causes, as the distribution of land and water, their different powers of absorption and radiation, together with the form, texture, and clothing of the land, and the prevailing winds,

it is found that the isothermal lines, or imaginary lines drawn through places on the surface of the globe which have the same mean annual temperature, do not correspond with the parallels of latitude. Thus in North America the climate is much colder than in the corresponding European latitudes. Quebec is in the latitude of Paris, and the country is covered with deep snow four or five months in the year, and it has occurred that a summer has passed there in which not more than 60 days have been free from frost.

In the southern hemisphere, beyond the 34th parallel, the summers are colder and the winters milder than in corresponding latitudes of the northern hemisphere. Neither does the temperature of mountains vary exactly with their height above the sea; other causes, as prevailing winds, difference of radiation, and geological structure, concur in producing irregularities which have a powerful effect on the vegetable world.

However, no similarity of existing circumstances can account for whole families of plants being confined to one particular country, or even to a very limited district, which, as far as we can judge, might have grown equally well on many others. Latitude, elevation, soil, and climate, are but secondary causes in the distribution of the vegetable kingdom, and are totally inadequate to explain why there are numerous distinct botanical districts in the continents and islands, each of which has its own vegetation, whose limits are most decided when they

are separated by the ocean, mountain-chains, sandy deserts, salt-plains, or internal seas. Each of these districts is the focus of families and genera, some of which are found nowhere else, and some are common to others, but, with a very few remarkable exceptions, the species of plants in each are entirely different or representative.[1] This does not depend

[1] M. de Candolle established 20 botanical regions, and Professor Schow the same number; but Professor Martius, of Munich, has divided the vegetation of the globe into 51 provinces, namely, 5 in Europe, 11 in Africa, 13 in Asia, 3 in New Holland, 4 in North and 8 in South America, besides Central America, the Antillas, the Antarctic Lands, New Zealand, Van Diemen's Land, New Guinea, and Polynesia. To these, other divisions might be added, as the Galapagos, which is so strongly defined.

Baron Humboldt gives the following concise view of the distribution of plants, both as to height and latitude:—

The equatorial zone is the region of palms and bananas.

The tropical zone is the region of tree-ferns and figs.

The subtropical zone, that of myrtles and laurels.

The warm temperate zone, that of evergreen trees.

The cold temperate zone, that of European or deciduous trees.

The subarctic zone, that of pines.

The arctic zone, that of rhododendrons.

The polar zone, that of alpine plants.

Upper Limit of Trees on Mountains.—The upper limit of trees is distinguished by the Escalloniæ, on the Andes of Quito, at the height of 11,500 feet above the level of the sea.

In tropical Mexico the upper limit of trees, at the height of 12,789 feet, is distinguished by the Pinus occidentalis.

In the temperate zone the limit of trees is marked by the Quercus Semicarpifolia, at 11,500 feet, on the south side of the Himalaya, and by the Betula Alba, on the north side, at the height of 14,000 feet: the same birch forms the limit on the

upon the difference in latitude, for the vegetation of the United States of North America is totally unlike that of Europe under the same isothermal lines, and even between the tropics the greatest dissimilarity often prevails under different degrees of longitude: consequently the cause of this partial distribution of plants, and that of animals also, which is according to the same law, must be looked for in those early geological periods when the earth first began to be tenanted by the present races of organised beings.

As the land rose at different periods above the ocean, each part, as it emerged from the waves,

Caucasus, at the elevation of 6394 feet. On the Pyrenees and Alps the limit is marked by the Coniferæ or pine tribe: on the Pyrenees by the Pinus uncinata, at the height of 10,870 feet; on the south side of the Alps by the larch, at the elevation of 6700 feet; and by the Pinus abies, at 5883 feet, on the north.

In Lapland the Betula Alba forms the upper limit of trees, at the height of only 1918 feet.

The upper Limit of Shrubs.—In the Andes of Quito the Bejarias are the shrubs that attain the greatest height, and terminate at 13,420 feet above the sea-level.

The juniper, Salix, and Ribes, or currant tribe, form the upper limit of shrubs on the south side of the Himalaya, at the height of 11,500 feet. The tama, or Genista versicolor, a species of broom, flourishes at the height of 17,000 feet on the north side, and vegetation is prolonged to nearly 18,000 feet.

The Rhododendron forms the upper limit of shrubs on the Caucasus, at 8825 feet; in the Pyrenees it grows to 8312 feet; in the Alps to 7480 feet; and in Lapland it forms the upper limit of shrubs at an elevation of 3000 feet above the Arctic Ocean.

had probably been clothed with vegetation, and peopled with animals, suited to its position with regard to the equator, and to the climate and condition of the globe then being. And as the conditions and climate were different at each succeeding geological epoch, so each portion of the land, as it rose, would be characterized by its own vegetation and animals, and thus at last there would be many centres of creation, as at this day, all differing more or less from one another, and hence alpine floras must be of older date than those in the plains. The vegetation and faunas of those lands that differed most in age and place would be most dissimilar, while the plants and animals of such as were not far removed from one another in time and place would have correlative forms or family likenesses, yet each would form a distinct province. Thus, in opposite hemispheres, and everywhere at great distances, but under like circumstances, the species are representatives of one another, rarely identical: when, however, the conditions which suit certain species are continuous, identical species are found throughout, either by original creation or by migration. The older forms may have been modified to a certain extent by the succeeding conditions of the globe, but they never could have been changed, since immutability of species is a primordial law of nature. Neither external circumstances, time, nor human art, can change one species into another, though each to a certain extent is capable of accommodating itself to a change of external circum-

stances, so as to produce varieties even transmissible to their offspring.

The flora of Cashmere and the higher parts of the Himalaya mountains is similar to that of southern Europe, yet the species are representative, not identical. In the plains of Tartary, where from their elevation the degree of cold is not less than in the wastes of Siberia, the vegetation of one might be mistaken for that of the other; the gooseberry, currant, willow, rhubarb, and in some places the oak, hazel, cypress, poplar, and birch, grow in both, but they are of different species. The flora near the snow-line on the lofty mountains of Europe, and lower down, has also a perfect family likeness to that in high northern latitudes. In like manner many plants on the higher parts of the Chilian Andes are similar, and even identical, with those in Tierra del Fuego; nay, the Arctic flora has a certain resemblance to that of the Antarctic regions, and even occasional identity of species. These remarkable coincidences may be accounted for by the different places having been at an early geological period at the same level above the ocean, and that they continue to retain part of their original flora after their relative positions have been changed. The tops of the Chilian Andes were probably on a level with Tierra del Fuego when both were covered with the same vegetation, and in the same manner the lofty plains of Tartary may have acquired their vegetation when they were on the level of southern Siberia.

In the many vicissitudes the surface of the globe has undergone, continents formed at one period were broken up at another into islands and detached masses by inroads of the sea and other causes. Now Professor E. Forbes has shown that some of the primary floras and faunas have spread widely from their original centres over large portions of the continents before the land was broken up into the form it now has, and thus accounts for the similarity and sometimes identity of the plants and animals of regions now separated by seas,—as, for example, islands, which generally partake of the vegetation and fauna of the continents adjacent to them. Taking for granted the original creation of specific centres of plants and animals, Professor E. Forbes has clearly proved that "the specific identity, to any extent, of the flora and fauna of one area, with those of another, depends on both areas forming, or having formed, part of the same specific centre, or on their having derived their animal and vegetable population by transmission, through migration, over continuous or closely contiguous land, aided, in the case of alpine floras, by transportation on floating masses of ice."

By the preceding laws the limited provinces and dispersion of animal and vegetable life are explained, but the existence of single species in regions very far apart has not yet been accounted for.

Very few of the exogenous or dicotyledonous plants are common to two or more countries far apart: among the few, the Samolus Valerandi, a

common English plant, is a native of Australia; the Potentilla tridentata, not found in Britain, except on one hill in Angusshire, is common to Arctic Europe and the mountains of North America; and in the Falkland Islands there are more than 30 flowering plants identical with those in Great Britain.

There are many more instances of wide diffusion among the monocotyledonous plants, especially grasses: the Phleum alpinum of Switzerland grows without the smallest variation at the Straits of Magellan, and Mr. Bunbury met with the European quaking-grass in the interior of the country at the Cape of Good Hope; but the cellular or cryptogamous class is most widely diffused—plants not susceptible of cultivation, of little use to man, and of all others the most difficult to transport. The Sticta aurata, found in Cornwall, is a native of the Cape of Good Hope, St. Helena, the West Indian islands, and Brazil; the Trichomanes brevisetum, long supposed to be peculiar to the British isles, is ascertained to grow in Madeira, South America, &c.; and our eminent botanist, Mr. Brown, found 38 British lichens and 28 British mosses in New Holland, yet in no two parts of the world is the vegetation more dissimilar; and almost all the lichens brought from the southern hemisphere by Sir James Ross, amounting to 200 species, are also inhabitants of the northern hemisphere, and mostly European.

In islands far from continents the number of plants is small, but of these a large proportion occur nowhere else. In St. Helena, of 30 flower-bearing

plants, 1 or 2 only are native elsewhere, but in 60 species of cryptogamous plants Dr. Hooker found only 12 peculiar to the island.

Some plants are more particularly confined to certain regions: the species of Cinchona which furnish the Peruvian bark grow along the eastern declivity of the Andes, as far as 18° S. lat.; the cedar of Lebanon is indigenous on that celebrated mountain only; and the Disa grandiflora is limited to a very small spot on the top of the Table-mountain at the Cape of Good Hope; but whether these are remnants whose kindred have perished by a change of physical circumstances, or centres only beginning to spread, it is impossible to say.

Plants are dispersed by currents: of 600 plants from the vicinity of the river Zaire on the coast of Africa, 13 are found also on the shores of Guiana and Brazil, evidently carried by the great equatorial current to countries congenial in soil and climate. The seeds of the Mimosa scandens, the Guilandina Bonduc, and the cashew-nut, are wafted from the West India islands to the coasts of Scotland and Ireland by the Gulf-stream, a climate and soil which do not suit them, therefore they do not grow. Of all the great orders, the species of Leguminosæ are most widely dispersed on coasts, because their seeds are not injured by the water. Winds also waft seeds to great distances; birds and quadrupeds, and above all man, are active agents in dispersing plants.

CHAPTER XXIV.

Vegetation of the Great Continent — Of the Arctic Islands — And of the Arctic and North Temperate Regions of Europe and Asia.

THE southern limit of the polar flora, on the great continent, lies mostly within the Arctic Circle, but stretches along the tops of the Scandinavian mountains, and reappears in the high lands of Scotland, Cumberland, and Ireland, on the summits of the Pyrenees, Alps, and other mountains in southern Europe, as well as on the table-land of eastern Asia, and on the high ridges of the Himalaya.

The great European plain to the Ural Mountains, as well as the low lands of England and Ireland, were at one period covered by a sea full of floating ice and icebergs, which made the climate much colder than it now is. At the beginning of that period the Scandinavian range, the other continental mountains, and those in Britain and Ireland, were islands of no great elevation, and were then clothed with the Arctic flora, or a representative of it, which they still retain now that they form the tops of the mountain-chains, and at that time both plants and animals were conveyed from one country to another by the floating ice. It is even probable, from the relations of the fauna and flora, that Greenland, Iceland, and the very high European latitudes, are the residue of a great northern land which had sunk

down at the close of the glacial period, for there were many vicissitudes of level during that epoch. At all events it may be presumed that the elevation of the Arctic regions of both continents, if not contemporaneous, was probably not far removed in time. Similarity of circumstances had extended throughout the whole Arctic regions, since there is a remarkable similarity and occasional identity of species of plants and animals in the high latitudes of both continents, which is continued along the tops of their mountain-chains, even in the temperate zones; and there is reason to believe that the relations between the faunas and floras of Boreal America, Asia, and Europe, must have been established towards the close of the glacial period.

The flora of Iceland approaches that of Britain, yet only one in four of the British plants are known in Iceland. There are 870 species in Iceland, of which more than half are flower-bearing: this is a greater proportion than is found in Scotland, but there are only 32 of woody texture. This flora is scattered in groups according as the plants like a dry, marshy, volcanic, or marine soil. Many grow close to the hot-springs; some not far from the edge of the basin of the Great Geyser, where every other plant is petrified; and species of Confervæ flourish in a spring said to be almost hot enough to boil an egg. The grains cannot be cultivated on account of the severity of the climate, but the Icelanders make bread from metur, a species of wild corn, and also from the bulbous root of Polygonum viviparum; their

greatest delicacy is the Angelica archangelica; Iceland moss, used in medicine, is an article of commerce. There are 583 species in the Feroe islands, of which 270 are flowering plants: many thrive there that cannot bear the cold of Iceland.

ARCTIC FLORA OF THE GREAT CONTINENTS.

In the most northern parts of the Arctic lands the year is divided into one long intensely cold night and one bright and fervid day, which quickly brings to maturity the scanty vegetation. Within the limit of perpetual congelation the Palmella nivalis (or red snow of Arctic voyagers), a very minute red or orange-coloured plant, finds nourishment in the snow itself, the first dawn of vegetable life; it is also found colouring large patches of snow in the Alps and Pyrenees.

Lichens are the first vegetables that appear at the limits of the snow-line, whether in high latitudes or mountain-tops, and they are the first vegetation that takes possession of volcanic lavas and new islands, where they prepare soil for plants of a higher order: they grow on rocks, stones, and trees, in fact on anything that affords them moisture. More than 2400 species are already known; no plants are more widely diffused, and none afford a more striking instance of the arbitrary location of species, as they are of so little direct use to man that they could not have been disseminated by his agency. The same

kinds prevail throughout the Arctic regions, and the species common to both hemispheres are very numerous. Some lichens produce brilliant red, orange, and brown dyes; and the tripe de roche, a species of Gyrophora, is a miserable substitute for food, as our intrepid countryman Sir John Franklin and his brave companions experienced in their perilous Arctic journey.

Mosses follow lichens on newly-formed soil, and they are found everywhere thoughout the world in damp situations, but in greatest abundance in temperate climates: 800 species are known, of which a great part inhabit the Arctic regions, constituting a large portion of the vegetation.

In Asiatic Siberia north of the 60th parallel of latitude the ground is perpetually frozen at a very small depth below the surface: a temperature of 70° below zero of Fahrenheit is not uncommon, and in some instances the cold has been 120° below zero. Then it is fatal to animal life, especially if accompanied by wind. In some places trees grow and corn ripens even at 70° of north latitude; but in the most northern parts boundless swamps, varied by lakes both of salt and fresh water, cover wide portions of this desolate country, which is buried under snow nine or ten months in the year. As soon as the snow is melted by the returning sun, these extensive morasses are covered with coarse grass and rushes, while mosses and lichens mixed with dwarf willows clothe the plains; saline plants abound, and whole districts produce Diotis ceratoides.

In Nova Zembla and other places in the far north the vegetation is so stunted that it barely covers the ground, but a much greater variety of minute plants of considerable beauty are crowded together there in a small space than in the alpine regions of Europe where the same genera grow. This arises from the weakness of the vegetation; for in the Swiss Alps the same plant frequently occupies a large space, excluding every other, as the dark-blue gentian, the violet-coloured pansy, the pink and yellow stone-crops. In the remote north, on the contrary, where vitality is comparatively feeble and the seeds do not ripen, thirty different species may be seen crowded together in a brilliant mass, no one having strength to overcome the rest. In such frozen climates plants may be said to live between the air and the earth, for they scarcely rise above the soil, and their roots creep along the surface, not having power to enter it. All the woody plants, as the Betula nana, the reticulated willow, Andromeda tetragona, with a few berry-bearing shrubs, trail along the ground, never rising more than an inch or two above it. The Salix lanata, the giant of these boreal forests, never grows more than five inches above the surface, while its stem, 10 or 12 feet long, lies hidden among the moss, owing shelter to its lowly neighbour.

The chief characteristic of the vegetation of the Arctic regions is the predominance of perennial and cryptogamous plants, and also of the sameness of its nature; but more to the south, where night begins to alternate with day, a difference of species appears

in longitude as well as in latitude. A beautiful flora of vivid colours adorns these latitudes both in Europe and Asia during their brief but bright and ardent summer, consisting of potentillas, gentians, chickweeds, saxifrages, sedums, Ranunculi, spiræas, drabas, artemisias, claytonias, and many more. Such is the power of the sun and the consequent rapidity of vegetation, that these plants spring up, blossom, ripen their seed, and die, in six weeks: in a lower latitude woody plants follow these, as berry-bearing shrubs, the glaucous Kalmia, the trailing Azalea, and rhododendrons. The Siberian flora differs from that in the same European latitudes by the North American genera Phlox, Mitella, Claytonia, and the predominance of asters, Solidago, Spiræa, milk-vetches, wormwood, and the saline plants goosefoot and saltworts.

Social plants abound in many parts of the northern countries, as grass, heath, furze, and broom: the steppes are an example of this on a very extensive scale. Both in Europe and Asia they are subject to a rigorous winter, with deep snow and chilling blasts of wind; and as the soil generally consists of a coating of vegetable mould over clay, no plants with deep roots thrive upon them; hence the steppes are destitute of trees, and even bushes are rare except in ravines: the grass is thin, but nourishing. Hyacinths and some other bulbs, mignonette, asparagus, liquorice, and wormwood, grow in the European steppes; the two last are peculiarly characteristic. The Nelumbium speciosum grows in one spot five

miles from the town of Astracan, and nowhere else in the wide domains of Russia: the leaves of this beautiful aquatic plant are often two feet broad, and its rose-coloured blossoms are very fragrant. It is also native in India and Tibet, where it is held sacred, as it was formerly in Egypt, where it is said to be extinct: it is one of the many instances of a plant growing in countries far apart.

Each steppe in Siberia has its own peculiar plants; the Peplis and Camphorosma are peculiar to the steppe of the Irtish, and the Amaryllis tatarica abounds in the meadows of eastern Siberia, where the vegetation bears a great analogy to that of north-western America: several genera and species are common to both.

Half the plants found by Wormskiold in Kamtchatka are European, with the exception of eight or ten, which are American. Few European trees grow in Asiatic Siberia, notwithstanding the similarity of climate, and most of them disappear towards the rivers Tobol and Irtish.

In Lapland and in the high latitudes of Russia large tracts are covered with birch-trees, but the pine and fir tribe are the principal inhabitants of the north. Prodigious forests of these are spread over the mountains of Norway and Sweden, and in European Russia 200,000,000 acres are clothed with these Coniferæ alone, or occasionally mixed with willows, poplars, and alders. Although soils of pure sand and lime are absolutely barren, yet they generally contain enough of alkali to supply the wants of

the fir and pine tribes, which require ten times less than oaks and other deciduous trees.

The Siberian steppes are bounded on the south by great forests of pine, birch, and willow: poplars, elms, and Tartarian maple overhang the upper courses of the noble rivers which flow from the mountains to the Frozen Ocean, and on the banks of the Yenessei the Pinus Cembra, or Siberian pine, with edible fruit, grows 120 feet high. The Altaï are covered nearly to their summit with similar forests, but on their greatest heights the stunted larch crawls on the ground, and the flora is like that of northern Siberia: round the lake Baikal the Pinus Cembra grows nearly to the snow-line.

Forests of black birch are peculiar to Dahuria, where there are also apricot and apple trees, and rhododendrons, of which a species grows in thickets on the hills, with yellow blossoms. Here and everywhere else throughout this country are found all the species of Caragana, a genus entirely Siberian. Each terrace of the mountains and each steppe on the plains has its peculiar plants, as well as some common to all: perennial plants are more numerous than annuals.

If temperature and climate depended upon latitude alone, all Asia between the 50th and 30th parallels would have a mild climate; but that is far from being the case, on account of the structure of the continent, which consists of the highest tablelands and the lowest plains on the globe.

The table-land of Tibet, where it is not culti-

vated, has the character of great sterility, and the climate is as unpropitious as the soil: frost, snow, and sleet begin early in September, and continue with little interruption till May; snow, indeed, falls every month in the year. The air is always dry, because in winter moisture falls in the form of snow, and in summer it is quickly evaporated by the intense heat of the sun. The thermometer sometimes rises to 144° of Fahrenheit in the sun, and even in winter his direct rays have great power for an hour or two, so that a variation of 100° in the temperature of the air has occurred in twelve hours. Notwithstanding these disadvantages, there are sheltered spots which produce most of the European grain and fruits, though the natural vegetation bears the Siberian character, but the species are quite distinct. The most common indigenous plants are Tartarian furze and various prickly shrubs resembling it, gooseberries, currants, hyssop, dog-rose, dwarf sow-thistle, Equisetum, rhubarb, lucern, and asafœtida, on which the flocks feed. Prangos, an umbelliferous plant with broad leaves and scented blossom, is peculiar to Ladak and other parts of Tibet. Mr. Moorcroft says it is so nutritious, that sheep fed on it become fat in twenty days. There are three species of wheat, three of barley, and two of buckwheat, natives of the lofty table-land, where the sarsinh is the only fruit known to be indigenous. Owing to the rudeness of the climate trees are not numerous, yet on the lower declivities of some mountains there are aspens, birch, yew, ash, Tartaric oak, various

pines, and the Pavia, a species of horse-chestnut. Much of the table-land of Tartary is occupied by the Great Gobi and other deserts of sand, with grassy steppes near the mountains; but of the flora of these regions we know nothing.

FLORA OF BRITAIN AND OF MIDDLE AND SOUTHERN EUROPE.

The British islands afford an excellent illustration of distinct provinces of animals and plants, and also of their migration from other centres. Professor E. Forbes has determined five botanical districts, four of which are restricted to limited provinces, whilst the fifth, which comprehends the great mass of British plants, is everywhere, either alone or mixed with the others. All of these, with a very few doubtful exceptions, have migrated before the British islands were separated from the continent. The first, which is of great antiquity, includes the flora of the mountain districts of the west and south-west of Ireland, and is similar to that in the south of Spain, but the more delicate plants had been killed by the change of climate after the separation of Ireland from the Asturias. The flora in the south of England and the south-east of Ireland is different from that in all other parts of the British islands; it is intimately related to the vegetation of the Channel Islands and the coast of France opposite to them, yet there are many plants in the Channel Islands which are not in-

digenous in Britain. In the south-west of England, where the chalk-plants prevail, the flora is like that on the adjacent coast of France.

The tops of the Scottish mountains are the focus of a separate flora, which is the same with that in the Scandinavian Alps, and is very numerous. Scotland, Wales, and a part of Ireland received this flora when they were groups of islands in the Glacial Sea. The rare Eriocaulon is found in the Hebrides, in Connemara, and in Northern America, and nowhere else. Some few individuals of this flora grow on the summits of the mountains in Cumberland and Wales. The fifth, of more recent origin than the alpine flora, including all the ordinary flowering plants, as the common daisy and primrose, hairy ladies' smock, upright meadow crowfoot, and the lesser celandine, together with our common trees and shrubs, has migrated from Germany before England was separated from the continent of Europe by the British Channel. It can be distinctly traced in its progress across the island, but the migration was not completed till after Ireland was separated from England by the Irish Channel, and that is the reason why many of the ordinary English plants, animals, and reptiles are not found in the sister island, for the migration of animals was simultaneous with that of plants, and took place between the last of the tertiary periods and the historical epoch, that of man's creation: it was extended also over a great part of the continent.[1]

[1] The British flora contains at least 3000 species.

Deciduous trees are the chief characteristic of the temperate zone of the old continent, more especially of middle Europe; these thrive best in soil produced by the decay of the primary and ancient volcanic rocks, which furnish abundance of alkali. Oaks, elms, beech, ash, larch, maple, lime, alder, and sycamore, all of which lose their leaves in winter, are the prevailing vegetation, occasionally mixed with fir and pine.

The undergrowth consists of wild apple, cherry, yew, holly, hawthorn, broom, furze, wild rose, honeysuckle, clematis, &c. The most numerous and characteristic herbaceous plants are the umbelliferous class, as carrot and anise, the campanulas, the Cichoraceæ, a family to which lettuce, endive, dandelion, and sow-thistle belong. The cruciform tribe, as wallflower, stock, turnip, cabbage, cress, &c., are so numerous, that they form a distinguishing feature in the botany of middle Europe, to which 45 species of them belong. This family is almost confined to the northern hemisphere, for, of 800 known species, only 100 belong to the southern, the soil of which must contain less sulphur, which is indispensable for these plants.

In the Pyrenees, Alps, and other high lands in Europe, the gradation of botanical forms, from the summit to the foot of the mountains, is similar to that which takes place from the Arctic to the middle latitudes of Europe. The analogy, however, is true only when viewed generally, for many local circumstances of climate and vegetation interpose;

and although the similarity of botanical forms is very great between certain zones of altitude and parallels of latitude, the species are for the most part different.

Evergreen trees and shrubs become more frequent in the southern countries of Europe, where about a fourth part of the ligneous vegetation never entirely lose their leaves. The flora consists chiefly of ilex, oak, cypress, hornbeam, sweet chestnut, laurel, laurustinus, the apple tribe, manna or the flowering ash, carob, jujube, juniper, terebinths, lentiscus and pistaccio which yield resin and mastic, arbutus, myrtle, jessamine (yellow and white), and various pines, as the Pinus maritima, and Pinus Pinea, or stone pine, which forms so picturesque a feature in the landscape of southern Europe. The most prevalent herbaceous plants are Caryophylleæ, as pinks, Stellaria, and arenarias, and also the labiate tribe, mint, thyme, rosemary, lavender, with many others, all remarkable for their aromatic properties, and their love of dry situations. Many of the choicest plants and flowers which adorn the gardens and grounds in northern Europe are indigenous in these warmer countries: the anemone, tulip, mignonette, narcissus, gladiolus, iris, asphodel, amaryllis, carnation, &c. In Spain, Portugal, Sicily, and the other European shores of the Mediterranean, tropical families begin to appear in the arums, plants yielding balsams, oleander, date and palmetto palms, and grasses of the group of Panicum or millet, Cyperaceæ or sedges, Aloe and Cactus. In this zone of transition there are six herbaceous for one woody plant.

FLORA OF TEMPERATE ASIA.

The vegetation of western Asia approaches nearly to that of India at one extremity, and Europe at the other; of 281 genera of plants which grow in Asia Minor and Persia, 109 are European. Syria and Asia Minor form a region of transition, like the other countries on the Mediterranean, where the plants of the temperate and tropical zones are united. We owe many of our best fruits and sweetest flowers to these regions. The cherry, almond, oleander, syringa, locust-tree, &c., come from Asia Minor; the walnut, peach, melon, cucumber, hyacinth, ranunculus, come from Persia; the date-palm, fig, olive, mulberry, and damask rose, come from Syria; the vine and apricot are Armenian, the latter grows also everywhere in middle and northern Asia. The tropical forms met with in more sheltered places are the sugar-cane, date and palmetto palms, mimosas, acacias, Asclepias gigantea, and arborescent Apocineæ. On the mountains south of the Black Sea, American types appear in rhododendrons and the Azalea pontica, and herbaceous plants are numerous and brilliant in these countries.

The table-land of Persia, though not so high as that of eastern Asia, resembles it in the quality of the soil, which is chiefly clayey, sandy, or saline, and the climate is very dry; hence vegetation is poor, and consists of thorny bushes, acacias, mimosas, tamarisk, jujube, and asafœtida. Forests of oak

cover the Lusistan mountains, but the date-palm is the only produce of the parched shores of the Arabian Gulf and of the oases on the Persian table-land. In the valleys, which are beautiful, there are clumps of Oriental plane and other trees, hawthorn, tree-roses, and many of the odoriferous shrubs of Arabia Felix.

Afghanistan produces the seedless pomegranate, acacias, date-palms, tamarisks, &c. The vegetation has much the same general character as that of Egypt. The valleys of the Hindoo Coosh are covered with clover, thyme, violets, and many odoriferous plants: the greater part of the trees in the mountains are of European genera, though all the species of plants, both woody and herbaceous, are peculiar. The small leguminous plant from whose leaves and twigs the true indigo dye is extracted grows spontaneously on the lower offsets of the Hindoo Coosh. This dye has been in use in India from the earliest times, but the plant which produces it was not known in England till towards the end of the 16th century. Since that time it has been cultivated in the West Indies and tropical America, though in that country there is a species indigenous.

Hot arid deserts bound India on the west, where the stunted and scorched vegetation consists of tamarisks, thorny acacia, deformed Euphorbiæ, and almost leafless thorny trees, shaggy with long hair, by which they imbibe moisture and carbon from the atmosphere. Indian forms appear near Delhi, in the genera Flacourtia and others, mixed with Syrian

plants. East of this transition the vegetation becomes entirely Indian, except on the higher parts of the mountains, where European types prevail.

The Himalaya mountains form a distinct botanical district. Immediately below the snow-line the flora is almost the same with that on the high plains of Tartary, to which may be added rhododendrons and andromedas, and among the herbaceous plants primroses appear. Lower down vast tracts are covered with prostrate bamboos, and European forms become universal, though the species are Indian, as gentians, plantagos, campanulas, and gale. There are extensive forests of Coniferæ, consisting chiefly of Pinus excelsa, Deodora, and Morinda, with many deciduous forest and fruit trees of European genera. A transition from this flora to a tropical vegetation takes place between the altitudes of 9000 and 5000 feet, because the rains of the monsoons begin to be felt in this region, which unites the plants of both. Here the scarlet and other rhododendrons grow luxuriantly; walnuts, and at least 25 species of oak, attain a great size, one of which, the Quercus semicarpifolia, has a clean trunk from 80 to 100 feet high. Geraniums and labiate plants are mixed in sheltered spots with the tropical genera of Scitamineæ, or the ginger tribe; bignonias and balsams, and camellias, grow on the lower part of this region.

It is remarkable that Indian, European, American, and Chinese forms are united in this zone of transition, though the distinctness of species still obtains: the Triosteum, a genus of the honeysuckle

tribe, is American; the Abelia, another genus of the same, together with the Camellia and Tricyrtis, are peculiarly Chinese; the daisy and wild thyme are European. A few of the trees and plants mentioned descend below the altitude of 5000 feet, but they soon disappear on the hot declivities of the mountain, where the Erythrina monosperma and Bombax heptaphyllum are the most common trees, together with the Millingtoniæ, a tribe of large timber-trees, met with everywhere between the Himalaya and 10° N. lat. The Shorea robusta, Dalbergia, and Cedrela, a genus allied to mahogany, are the most common trees in the forests of the lower regions of these mountains.

The temperate regions of eastern Asia, including Chinese Tartary, China, and Japan, have a vegetation totally different from that of any other part of the globe similarly situated, and show in a strong point of view the distinct character which vegetation assumes in different longitudes. In Mandshuria and the vast mountain-chains that slope from the eastern extremity of the high Tartarian table-land to the fertile plains in China, the forests and flora are generally of European genera, but Asiatic species; in these countries the buckthorn and honeysuckle tribes are so numerous as to give a peculiar character to the vegetation. Mixed with these and with roses are thickets of azaleas covered with blossoms of dazzling brightness and beauty.

The transition zone in this country lies between the 35th and 27th parallels of north latitude, in

which the tropical flora is mixed with that of the northern provinces. The prevailing plants on the Chinese low grounds are Glycine, Hydrangea, the camphor laurel, Stillingia sebifera, or wax-tree, Clerodendron, Hibiscus Rosa-sinensis, Thuia orientalis, Olea fragrans, the sweet blossoms of which are mixed with the finer teas to give them flavour; Melia azedarach, or Indian pride, the paper mulberry, and others of the genus, and Camellia sasanqua, which covers hills in the province of Kiong-si. The tea-plant, and other species of Camellia, grow in many parts; the finest tea is the produce of a low range of hills from between the 33rd and 25th parallels, an offset from the great chain of Peling. Thea viridis and bohea are possibly only varieties of the same plant; the green tea is strong and hardy, the black a small delicate plant. The quality of the tea depends upon the stage of growth at which it is gathered; early leaves make the best tea, those picked late in the season give a very coarse tea. Bohea grows in the province of Fu-kian, hyson in Song-lo. Pekoe or pak-ho, which means white down in Chinese, consists of the first downy sprouts or leaf-buds of three-years-old plants. A very costly tea of this kind, never brought to Europe, and known as the tea of the Wells of the Dragon, is used only by persons of the highest rank in China. The true Imperial tea also, called Flos theæ, which is not, as was supposed, the flower-buds, but merely a very superior quality of tea, seldom reaches Europe; that sold under this name is really Chusan tea

flavoured with blossoms of Olea fragrans.[1] The Chinese keep tea a year before they use it, because fresh tea has an intoxicating quality which produces disturbance of the nervous system like the effect of Erythroxylon Coca on the Peruvians. It is a remarkable circumstance that tea and coffee, belonging to different families, natives of different quarters of the globe, should possess the same principle, and it is not less remarkable that their application to the same use should have been so early discovered by man.

The tea-plant grows naturally in Japan and upper Assam; it is hardy and possesses great power of adaptation to climate. It has lately been cultivated in Brazil, in Provence, and in Algiers, but at an expense which renders it unprofitable. Tea comes to Europe almost exclusively from China, but the plant thrives so well in the north-western provinces of India that the English will ultimately compete with the Chinese in producing it, especially for the consumption of Tibet. Tea was first brought to Europe by the Dutch in 1610; a small quantity came to England in 1666, and now the annual con-

[1] The plants with which the Chinese give flavour to tea are the Olea fragrans, Chloranthus inconspicuus, Gardenia florida, Aglaia odorata, Mogorium sambac, Vitex spicata, Camellia sasanqua, Camellia odorifera, Illicium anisatum, Magnolia yulan, Rosa indica odoratissima, turmeric, oil of Bixa orellana, and the root of the Florentine iris.

The principles of caffeine and theine are in all respects identical.

sumption of tea in Great Britain is about fifty millions of pounds.[1]

The climate of Japan is milder than its latitude would indicate, owing to the influence of the surrounding ocean. European forms prevail in the high lands, as they do generally throughout the mountains of Asia and the Indian Archipelago, with the difference of species, as Abies, Cembra, Strobus, and Larix. The Japanese flora is similar to the Chinese, and there are 30 American plants, besides others of Indian and tropical climates. These islands, nevertheless, have their own peculiar flora, distinct in its nature; as the Sophora, Kerria, Aucuba, Mespilus, and Pyrus Japonica, Rhus vernix, Illicium anisatum, or the anise-tree, Daphne odorata, the soap-tree, various species of the Calycanthus tribe, the custard-apple, the Khair mimosa, which yields the catechu, the litchi, the sweet orange, the Cycas revoluta, a plant resembling a dwarf palm, with various other fruits. Many tropical plants mingle with the vegetation of the cocoanut and fan palms.

Thus the vegetation in Japan and China is widely different from that in the countries bordering the Mediterranean, though between the same parallels of latitude. In the tropical regions of Asia, where heat and moisture are excessive, the influence of latitude vanishes altogether, and the peculiarities of the vegetation in different longitudes become more evident.

[1] Davis on China.

CHAPTER XXV.

Flora of Tropical Asia — Of the Indian Archipelago, India, and Arabia.

TROPICAL Asia is divided by nature into three distinct botanical regions: the Malayan peninsula, with the Indian Archipelago; India, south of the Himalaya, with the island of Ceylon; and the Arabian peninsula. The two first have strong points of resemblance, though their floras are peculiar.

FLORA OF THE INDO-CHINESE PENINSULA AND THE INDIAN ARCHIPELAGO.

Many of the vegetable productions of the peninsula beyond the Ganges are the same with those of India, mixed with the plants of the Indian Archipelago, so that this country is a region of transition, though it has a splendid vegetation of innumerable native productions, dyes of the most vivid hues, spices, medicinal plants, and many with the sweetest perfume. The soil in many places yields three crops in the year; the fruits of India, and most of those of China, come to perfection in the low lands. The arang forms an exception to the extreme beauty of the multitude of palms which adorn the Malayan peninsula; though it is eminently characteristic of

that country, it is an ugly plant, covered with black fibres like horsehair, sufficiently strong to make cordage. It is cultivated for the sugar and wine made from its juice. Teak is plentiful; almost all that is used in Bengal comes from the Birman empire, though it is less durable than that of the Malabar coast. The Hopea odorata is so large that a canoe is made of a single trunk; the Gordonia integrifolia is held in such veneration that every Birman house has a beam of it.

There are seven species of native oak in the forests; the Mimosa catechu, which furnishes the terra japonica used in medicine; the trees which produce varnish and stick-lac; the Glyphyria nitida, a myrtle, the leaves of which are used as tea in Bencoolen, called by the natives the tree of long life. The coasts are wooded by the Heritiera robusta, a large tree which thrives within reach of the tide; bamboos with stems a foot and a half in diameter grow in dense thickets in the low lands. The Palmyra palm and the Borassus flabelliformis grow in extensive groves in the valley of the Irawaddy: it is a magnificent tree, often 100 feet high, remarkable for its gigantic leaves, one of which would shelter 12 men.

The anomalous trees the Zamias and Cycadeæ, somewhat like a palm with large pinnated leaves, but of a different family, are found here and in tropical India; those in America are of a different species. Orchideæ and tree-ferns are innumerable in the woody districts of the peninsula.

The vegetation of the Indian Archipelago is gorgeous beyond description; although in many instances it bears a strong analogy to that of the Malayan peninsula, tropical India, and Ceylon, still it is in an eminent degree peculiar. The height of the mountains causes variety in the temperature sufficient to admit of the growth of dammar pines, oaks, rhododendrons, magnolias, valerians, honeysuckles, bilberries, gentians, oleasters, and other European orders of woody and herbaceous plants; yet there is not one species in common.

Palm-trees are more abundant in these islands than in any other part of the world, especially in the Sunda group, the origin of many, a few of which are now widely spread over the eastern countries. Three species of Areca, attaining a height of from 40 to 50 and more feet, are cultivated in all the hot parts of India; and Caryota Urens, the fruit of which is acrid, yet it yields wine and sugar, are all native. The attempt is vain to specify the multitudes of these graceful trees which form so characteristic a feature in the vegetation of these tropical islands, where a rich moist soil with intense heat brings them to such perfection. It has been observed that monocotyledonous plants are generally more plentiful in islands than on continents, and also that they extend farther into the southern than into the northern hemisphere, which may be accounted for by the moist and mild climate of the former.

Jungle and dense pestilential woods entirely cover the smaller islands and the plains of the larger; the

coasts are lined with thickets of mangroves, a matted vegetation of forest-trees, bamboos, and coarse grass, entwined with climbing and creeping plants, and overgrown by orchideous parasites in myriads; and the gutta-percha is also a native of these alluvial tracts. The forest-trees of the Indian Archipelago are almost unknown; teak and many of the continental trees grow there, but the greater number are peculiarly their own. The naturalist Rumphius had a cabinet inlaid with 400 kinds of wood, the produce of Amboyna and the Molucca islands.

Sumatra, Java, and the adjacent islands are the region of the Dryobalanops camphora, in the stems of which solid lumps of a remarkable and costly kind of camphor are found. All the trees of that order, and of several others, are peculiar to these islands, and 78 species of trees and shrubs of the Melastomaceous tribe grow there and in continental India. There are thickets of the sword-leaved vaquois-tree and of the Pandanus or screw-pine, a plant resembling the anana, with a blossom like that of a bulrush, very odoriferous, and in some species edible.

This is the region of spices, which are very limited in their distribution: the Myristica moschata (the nutmeg and mace-plant) is confined to the Banda Islands, but it is said to have been discovered lately in New Guinea. The Amboyna and the Molucca groups are the focus of the Caryophyllus aromaticus, a myrtle, the buds of which are known as cloves. Various species of cinnamon and cassia, both of the laurel tribe, together with varieties of pepper, differ-

ent from those in India and Ceylon, grow in this archipelago. All the pepper-plants require great heat: they are rare in Africa, but plentiful in America and the Indian Archipelago; the common black pepper is peculiar to the hottest parts of Asia, extending only a few degrees on each side of the equator. In 1842 more than 30,000,000 pounds weight of pepper were produced in Sumatra alone. Some of the most excellent fruits are indigenous here only, as the dourio, the ayer ayer, Loquat, the choapa of Molucca, peculiar kinds of orange, lemon, and citron, with others known only by name elsewhere. Those common to the continent of India are the jambrose, rose-apple, jack, various species of bread-fruit, mango, mangosteen, and the banana, which is luxuriant.

Here the nettle tribe assume the most pernicious character, and the upas-tree of Java, one of the most deadly vegetable poisons; and even the plants resembling our common nettle are so acrid that the sting of one in Java occasions not only pain but illness, which lasts for days. A nettle in the island of Timor, called by the natives the "Devil's leaf," is so poisonous that it produces long illness and even death. The chelik, a shrub growing in the dense forests, produces a poison even more deadly than the upas. Some of the fig genus, which belongs also to the natural order of nettles, have acrid juices. Trees of the cashew tribe have a milky sap: the fine japan lacquer is made from the juice of the Stagmaria verniciflua. Barringtonia and palms are

very splendid here, the latter generally of peculiar species and limited in their distribution, as the Nipa. No country is richer in club-mosses and orchideous plants, which overrun the trees in thousands in the deep dark mountain-forests, choked by huge creeping plants, an undergrowth of gigantic grasses, through which not a ray of light penetrates.

Sir Stamford Raffles describes the vegetation of Java as "fearful." In these forests the air is heavy, charged with dank and deadly vapours, never agitated by a breath of wind; the soil, of the deepest black vegetable mould, always moist and clammy, stimulated by the fervid heat of a tropical sun, produces trees whose stems are of a spongy texture from their rapid growth, loaded with parasites, particularly the orchideous tribe, of which no less than 300 species are peculiar to that island. Tree-ferns are in the proportion of one to twenty of the other plants, and form a large portion of the vegetation of Java and all these islands; and there are above 200 tropical species of club-mosses growing to the length of 3 feet, whereas in cold countries they creep on the ground.

The Rafflesias, of which there are four species, are the most singular productions of this archipelago. The most extraordinary one is common to Java and Sumatra, where it was discovered by Dr. Arnold, and therefore is called Rafflesia Arnoldi. It is a parasitical plant, with buds the size of an ordinary cabbage, and the flower, which smells of carrion, is of a brick-red colour, 3½ feet in diameter: that

found by Mr. Arnold weighed 15 pounds, and the cup in its centre could contain 12 pints of liquid.

According to Sir Stamford Raffles there are six distinct climates in Java, from the top of the mountains to the sea, each having an extensive indigenous vegetation. No other country can show an equal abundance and variety of native fruit and esculent vegetables. There are 100 varieties of rice, and of fragrant flowers, shrubs, and ornamental trees the number is infinite. Abundant as the Orchideæ are in Java, Ceylon, and the Birmese empire, these countries possess very few that are common to them all, so local is their distribution. Ferns are more plentiful in this archipelago than elsewhere: tree-ferns are found chiefly between or near the tropics, in airless damp places.

INDIAN FLORA.

The plains of Hindostan are so completely sheltered from the Siberian blasts by the high table-lands of Tartary and the Himalaya mountains, that the vegetation at the foot of that range already assumes a tropical character. In the jungles and lower ridges of the fertile valley of Nepal, and on the dark and airless recesses of the Silhet forests, arborescent ferns and orchideous plants are found in profusion, scarcely surpassed even in the islands of the Indian Archipelago—indeed the marshy Tariyane is full of them. The lowest ranges of the Himalaya, the pestilential swamp of the Tariyane, the alluvial ridges of the hills that bound it on the south, and

many parts of the plains of the Ganges, are covered with primeval forests, which produce whole orders of large timber-trees, frequently overrun with parasitical loranths.

The native fruits of India are many; the orange tribe is almost all of Indian origin, though some of the species are now widely spread over the warmer parts of the other continents and the more distant countries of Asia. Two or three species are peculiar to Madagascar; one is found in the forests of the Essequibo and another in Brazil, which are the only exceptions known. The Limonia laureola grows on the tops of the high Asiatic mountains, which are covered with snow several months in the year; and the wampee, a fruit much esteemed in China and the Indian Archipelago, is produced by a species of this order. The vine grows wild in the forests; plantain, banana, jambrose, guava, mango, mangosteen, date, areca, palmyra, cocoa-nut, and gameto palms are all Indian, also the gourd family. The Scitamineæ, or ginger tribe, are so numerous, that they form a distinguishing and beautiful feature of Indian botany: they produce ginger, cardamoms, and turmeric. The flowers peculiar to India are brilliant in colours, but generally without odour, except the rose and some jessamines.

The greater part of the trees and plants mentioned belong also to tropical India, where vegetation is still more luxuriant; a large portion of that magnificent country, containing 1,000,000 square miles, has been cultivated time immemorial, although vast

tracts still remain in a state of nature. Those extensive mountain-chains which traverse and surround the Deccan are rich in primeval forests of stupendous growth with dense underwood. The most remarkable of these trees are the Indian cotton-tree and the Dombeya, which is of the same order; that which produces the Trincomalee wood, used for building boats at Madras; the red-wood tree, peculiar to the Coromandel coast, the satin-wood, the superb Butea frondosa, the agallochum tribe, which yields the odorous wood of aloes mentioned in Scripture, the Melaleuca leucadendron and the Melaleuca cajepute, from which the oil is prepared. The dragon's-blood tree is a native of India, though not exclusively, as some of the best specimens grow in Madagascar, where it is planted for hedges. Sanders-wood and dragon's-blood are obtained from the Pterocarpus sandalinus and Draco; the sappan-tree gives a purple dye: these are all of the leguminous or bean tribe, of which there are 452 Indian species: ebony grows in these tropical regions, in Mauritius, and the south coast of Africa.

Some of the fig tribe are among the most remarkable vegetable productions of India for gigantic size and peculiarity of form, which renders them valuable in a hot climate from the shade which their broad-spreading tops afford. Some throw off shoots from their branches, which take root on reaching the ground, and, after increasing in girth with wonderful rapidity, produce branches which also descend to form new roots, and this process is continued till a

forest is formed round the parent tree. Mr. Reinwardt saw in the island of Simao a large wood of the Ficus Benjamina which sprang from one stem. The Ficus Indica, or banyan-tree, is another instance of this wide-spreading growth; it is found in the islands, but is in greatest perfection around the villages in the Circar mountains: there is a tree of it on the banks of the Nerbudda, in the province of Guzerat, with 350 main stems, occupying an area of 2000 feet in circumference, independent of its branches, which extend much farther. The camphor genus is mostly Indian, as well as many more of the laurel tribe of great size. The banana is the most generally useful tree in this country; its fruit is food, its leaves are applied to many domestic purposes, and flax fit for making muslin is obtained from its stem. Cotton is a hairy covering of the seeds of several species of the mallow tribe which grow spontaneously in tropical Asia, Africa, and America; it is, however, cultivated in many countries beyond these limits. That grown in China and the United States of America is an herbaceous annual from 18 inches to 2 feet high: there are also cotton-trees, native and cultivated, in India, China, Africa, and America. Herodotus mentions cotton garments 445 years before the Christian era, and the Mexicans manufactured cotton cloth before the discovery of America.

Palms, the most stately and graceful of the vegetable productions of tropical regions, are abundant in India, in forests, in groups, and in single trees. Some species grow at the limit of perpetual snow,

some 900 feet above the sea, others in valleys and on the shores of the continent and islands. They decrease in number and variety as the latitude increases, and terminate at Nice, in 44° N. lat., their limit in the great continent. The leaves of some are of gigantic size, and all are beautiful, varying in height from the slender Calamus rotang, 130 feet high, to the Chamærops humilis, not more than 15 or 20. Different species yield wine, oil, wax, flour, sugar, thread, and rope; weapons and utensils are made of their stems and leaves; they serve for the construction of houses; the cocoa-nut palm gives food and drink; sago is made from all except the Areca catechu, the fruit of which, the betel-nut, is used by the natives for its intoxicating quality.

Though palms in general are very limited in their distribution, a few species are very widely spread; for example, the cocoa-nut palm, which grows spontaneously on the southern coasts of the Indo-Chinese peninsula and the Sunda Islands, from whence it has been carried to all the intertropical regions of the globe, where it has been extensively cultivated from its usefulness. So luxuriant is its growth in Ceylon that in one year nearly 3,000,000 of nuts were exported; in parts of that island, on the Malabar and Coromandel coasts, and in some districts in Bengal, the Borassus flabelliformis supplies its place.

The island of Ceylon, which may be regarded as the southernmost extremity of the Indian peninsula, is very mountainous, and rivals the islands of the Indian Archipelago in luxuriance of vegetable pro-

ductions, and in some respects bears a strong resemblance to them. The laurel, the bark of which is cinnamon, is indigenous, and one of the principal sources of the revenue of Ceylon. The taleput leaves of a species of palm are of such enormous size, that they are applied to many uses by the Cingalese: in ancient times strips of the leaf were written upon with a sharp style, and served as books. The sandal-wood of Ceylon is of a different species from that of the South Sea islands, and its perfume more esteemed. Indigo is indigenous, and so is the choya, whose roots give a scarlet dye. The mountains produce a great variety of beautiful woods used in cabinet-work. It is a remarkable circumstance in the distribution of plants, that the orchideæ are very numerous in this island.

ARABIAN VEGETATION.

The third division of the tropical flora of Asia is the Arabian, which differs widely from the other two, and is chiefly marked by trees yielding balsams. Oceans of barren sand extend to the south, from Syria through the greater part of Arabia, varied only by occasional oases in those spots where a spring of water has reached the surface; there the prevalent vegetation consists of the grasses, Holcus and Panicum dicotomum growing under the shade of the date-palm; mimosas and stunted prickly bushes appear here and there in the sand. There is verdure on the mountains, and along some of the coasts, especially in the province of Yemen, which has a

flora of its own. The Keura odorifera, a superb tree, with agreeable perfume, eight species of figs, the three species of Amyris—gileadensis, or balm of Gilead, opobalsamum also yielding balsam, and the kataf, from which myrrh is supposed to come—are peculiar to Arabia. Frankincense is said to be the produce of the Boswellia serrata; and there are many species of Acacia, among others the Acacia arabica, which produces gum arabic. The arak and tamarind trees connect the botany of Arabia with that of the West Indies, while it is connected with that of the Cape of Good Hope by Stapelias, mesembryanthemums, and liliaceous flowers. The character of Arabian vegetation, like that of other dry hot climates, consists in its odoriferous plants and flowers.

Arabia produces coffee, which, however, is not indigenous, but is supposed to have come from the table-land of Ethiopia, and to have its name from the province of Kaffa, where it forms dense forests. It was introduced into Arabia in the end of the fifteenth century, and grows luxuriantly in Arabia Felix, where the coffee is of the highest flavour. Most of that now used is the progeny of plants raised from seed and brought from Mocha to the Botanic Garden at Amsterdam in 1690, by Van Hoorn, Governor of Batavia. A plant was sent to Louis XIV., in 1714, by the magistrates of Amsterdam—it was from this plant that the first coffee-plants were introduced in 1717 into the West India islands. A year afterwards the Dutch introduced coffee-trees into Surinam, from whence they spread rapidly over

the warm parts of America and the West India islands. Many thousands of people are now employed in its cultivation there, in Demerara, Java, Manilla, the isle of Bourbon, and other places. More than 3,000,000 pounds of coffee-beans are produced, and 100,000 tons of shipping are annually employed in its transport across the Indian and Atlantic Oceans. Coffee was not known till many centuries after the introduction of sugar. The first coffee-house was opened in London in 1652, and the first in France, at Marseilles, in 1671.

CHAPTER XXVI.

African Flora—Flora of Australia, New Zealand, Norfolk Island, and of Polynesia.

The northern coast of Africa, and the range of the Atlas generally, may be regarded as a zone of transition, where the plants of southern Europe are mingled with those peculiar to the country; half the plants of northern Africa are also found in the other countries on the shores of the Mediterranean. Of 60 trees and 248 shrubs which grow there, 100 only are peculiar to Africa, and about 18 of these belong to its tropical flora. There are about six times as many herbaceous plants as there are trees and shrubs; and in the Atlas mountains, as in other chains, the perennial plants are much more numerous than annuals. Evergreens predominate, and are the same as those on the other shores of the Mediterranean. The pomegranate, the locust-tree, the oleander, and the palmetto abound; and the cistus tribe give a distinct character to the flora. The sandarach, or Thuia articulata, peculiar to the northern side of the Atlas mountains and to Cyrenaica, yields close-grained hard timber, used for the ceiling of mosques, and is supposed to be the shittim-wood of Scripture. The Atlas produces seven or eight species of oak, various pines, especially the Pinus maritima, and forests of the Aleppo pine in Algiers. The

sweet-scented arborescent heath and Erica scoparia are native here, also in the Canary Islands and the Azores, where the tribe of house-leeks characterises the botany. There are 534 phanerogamous plants, or such as have the parts of fructification evident, in the Canary Islands; of these 310 are indigenous, the rest African: the Pinus canariensis is peculiar, and also the Dracænæ, which grow in perfection here. The stem of the Dracæna Draco, of the Villa Oratava in Teneriffe, measures 46 feet in circumference at the base of the tree, which is 75 feet high. It is known to have been an object of great antiquity in the year 1402, and is still alive, bearing blossoms and fruit. If it be not an instance of the partial location of plants, there must have been intercourse between India and the Canary Islands in very ancient times.

Plants with bluish-green succulent leaves are characteristic of tropical Africa and its islands; and though the group of the Canaries has plants in common with Spain, Portugal, Africa, and the Azores, yet there are many species, and even genera, which are found in them only; and the height of the mountains causes much variety in the vegetation.

On the continent, south of the Atlas, a great change of soil and climate takes place; the drought on the borders of the desert is so excessive that no trees can resist it, rain hardly ever falls, and the scorching blasts from the south speedily dry up any moisture that may exist; yet, in consequence of what descends from the mountains, the date-palm forms

large forests along their base, which supply the inhabitants with food, and give shelter to crops which could not otherwise grow. The date-palm, each tree of which yields from 150 to 160 pounds weight of fruit, grows naturally, and is also cultivated, through northern Africa. It has been carried to the Canary Islands, Arabia, the Persian Gulf, and to Nice, the most northern limit of the palm-tribe. Stunted plants are the only produce of the desert, yet large tracts are covered with the Pennisetum dichotomum, a harsh prickly grass, which, together with the Alhagi maurorum, is the food of camels.

The plants peculiar to Egypt are acacias, mimosas, cassias, tamarisks, the Nymphæa Lotus, the blue Lotus, the Papyrus, from which probably the first substance used for writing upon was made, and has left its name to that we now use; also the Zizyphus or jujub, various mesembryanthemums, and most of the plants of Barbary grow here. The date-palm is not found higher on the Nile than Thebes, where it gives place to the doom-palm, or Cucifera Thebaica, peculiar to this district, and singular as being the only palm that has a branched stem.

The eastern side of equatorial Africa is less known than the western, but the floras of the two countries, under the same latitude, have little affinity: on the eastern side the Rubiaceæ, the Euphorbiæ, a race peculiarly African, and the Malvaceæ, are most frequent. The genus Danais of the coffee tribe distinguishes the vegetation of Abyssinia, also the Dombeya, a species of vine, various jessamines, a

beautiful species of honeysuckle; and Bruce says a caper-tree grows to the height of the elm, with white blossoms, and fruit as large as a peach. The daroo, or Ficus sycomorus, and the arak-tree, are native. The kollquall, or Euphorbia antiquorum, grows 40 feet high on the plain of Baharnagach, in the form of an elegant branched candelabrum, covered with scented fruit. The kantuffa or thorny shrub, is so great a nuisance from its spines, that even animals avoid it. The Erythrina Abyssinica bears a poisonous red bean with a black spot, used by the Shangalla and other tribes for ages as a weight for gold, and by the women as necklaces. Mr. Rochet has lately brought some seeds of new grain from Shoa, that are likely to be a valuable addition to European cerealia.

The vegetation of tropical Africa on the west is known only along the coast, where some affinity with that of India may be observed. It consists of 573 species of flower-bearing plants, and is distinguished by a remarkable uniformity, not only in orders and genera, but even in species, from the 16th degree of N. lat. to the river Congo in 6° S. lat. The most prevalent are the grasses and bean tribes, the Cyperaceæ Rubiaceæ, and the Compositæ. The Adansonia, or baobab of Senegal, is one of the most extraordinary vegetable productions; the stem is sometimes 34 feet in diameter, though the tree is rarely more than 50 or 60 feet high; it covers the sandy plains so entirely with its umbrella-shaped top, that a forest of these trees presents a compact surface, which at some distance seems to be a green field. Cape Verde has its

name from the numbers that conceal the barren soil under their spreading tops; some of them are very old, and, with the dragon-tree at Teneriffe, are supposed to be the most ancient vegetable inhabitants of the earth. The Pandanus candelabrum, instead of growing crowded together in masses like the baobab, stands solitary on the equatorial plains, with its lofty forked branches ending in tufts of long stiff leaves. Numerous sedges, of which the Papyrus is the most remarkable, give a character to this region, and cover boundless plains, waving in the wind like corn-fields, while other places are overgrown by forests of gigantic grasses with branching stems.

A rich vegetation, consisting of impenetrable thickets of mangrove, the poisonous manchineel, and many large trees, cover the deltas of the rivers, and even grow so far into the water, that their trunks are coated with shell-fish; but the pestilential exhalations render it almost certain death to botanize in this luxuriance of nature.

Various kinds of the soap or sapodilla trees are peculiar to Africa; the butter-tree of the enterprising but unfortunate Mungo Park, the star-apple, the cream-fruit, the custard-apple, and the water-vine, are plentiful in Senegal and Sierra Leone. The ibraculea is peculiarly African; its seeds are used to sweeten brackish water. The safu and bread-fruit of Polynesia are represented here by the musanga, a large tree of the nettle tribe, the fruit of which has the flavour of the hazel-nut. A few palms have very local habitations, as the Elais Guineensis, or palm-oil

plant, found only on that coast. That graceful tribe is less varied in species in equatorial Africa than in the other continents. It appears that a great part of the flora of this portion of Africa is of foreign origin.

The flora of south Africa differs entirely from that of the northern and tropical zones, and as widely from that of every other country, with the exception of Australia and some parts of Chile. The soil of the table-land at the Cape of Good Hope, stretching to an unknown distance, and of the Karoo plains and valleys between the mountains, is sometimes gravelly, but more frequently is composed of sand and clay; in summer it is dry and parched, and most of its rivers are dried up; it bears but a few stunted shrubs, some succulent plants and mimosas, along the margin of the river-courses. The sudden effect of rain on the parched ground is like magic: it is recalled to life, and in a short time is decked with a beautiful and peculiar vegetation, comprehending, more than any other country, numerous and distinctly defined foci of genera and species.

Twelve thousand species of plants have been collected in the colony of the Cape in an extent of country about equal to Germany. Of these, heaths and proteas are two very conspicuous tribes; there are 300 species of the former, and 200 of the latter, both of which have nearly the same limited range, though Mr. Bunbury found two heaths, and the Protea cynaroides, the most splendid of the family (bearing a flower the size of a man's hat), on the

hills round Graham's Town, in the eastern part of the colony. These two tribes of plants are so limited that there is not one of either to be seen north of the mountains which bound the Great Karoo, and by much the greatest number of them grew within 100 miles of Cape Town; indeed at the distance of only 40 miles the prevailing Proteaceæ are different from those at the Cape. The Leucadendron argenteum, or silver-tree, which forms groves at the back of the table-mountain, is confined to the peninsula of the Cape. The beautiful Disa grandiflora is found only in one particular place on the top of the table-mountain.

The dry sand of the west coast and the country northward through many degrees of latitude is the native habition of Stapelias, succulent plants with square leafless stems, and flowers like star-fish, with the smell of carrion. A great portion of the eastern frontier of the Cape colony and the adjacent districts is covered with extensive thickets of a strong succulent and thorny vegetation, called by the natives the bush: similar thickets occur again far to the west, on the banks of the river Gauritz. The most common plants of the bush are aloes of many species, all exceedingly fleshy and some beautiful; the great red-flowering arborescent aloe, and some others, make a conspicuous figure in the eastern part of the colony. Other characteristic plants of the eastern districts are the spek-boem, or Portulacaria afra, Schotia speciosa, and the great succulent euphorbias, which grow into real trees 40 feet high,

branching like a candelabrum, entirely leafless, prickly, and with a very acrid juice. The Euphorbia meloformis, three feet in diameter, lies on the ground, to which it is attached by slender fibrous roots, and is confined to the mountains of Graaf Reynet. Euphorbias, in the Old World, correspond with the Cactus tribe, which belong exclusively to the New. The Zamia, a singular plant, having the appearance of a dwarf-palm without any real similarity of structure, belongs to the eastern districts, especially to the great tract of bush on the Caffir frontier.

Various species of Acacia are indigenous and much circumscribed in their location: the Acacia horrida, or the white-thorned acacia, is very common in the eastern districts and in Caffirland. The Acacia cafra is strictly eastern, growing along the margins of rivers, to which it is a great ornament. The Acacia detinens, or hook-thorn, is almost peculiar to Zand valley.

It appears from the instances mentioned that the vegetation in the eastern districts of the colony differs from that on the western, yet many plants are generally diffused of orders and genera found only in this part of Africa:—Nearly all the 300 species of the fleshy succulent tribe of Mesembryanthemum, or Hottentots' fig; a great many beautiful species of the Oxalis, or wood-sorrel tribe; every species of Gladiolus, with the exception of that in the corn-fields in Italy and France; ixias innumerable, one with petals of apple-green colour; geraniums, espe-

cially the genus Pelargonium, or stork's bill, almost peculiar to this locality; many varieties of Gnaphalium and Xeranthemum; the brilliant Strelitzia; 133 species of the house-leek tribe, all fleshy, attached to the soil by a strong wiry root, and nourished more or less from the atmosphere: Diosmas are widely scattered in great variety; shrubby Boragineæ with flowers of vivid colours, and Orchideæ with large and showy blossoms. The leguminous plants and the Cruciferæ of the Cape are peculiar; indeed all the vegetation has a distinct character, and both genera and species are confined within narrower limits than anywhere else, without any apparent cause to account for a dispersion so arbitrary.

Notwithstanding the peculiarity of character with which the botany of the Cape is so distinctly marked, it is connected with that of very remote countries by particular plants; for example, of the seven species of bramble which grow at the Cape, one is the common English bramble or blackberry. The affinity with New Holland is greater: in portions of the two countries in the same latitude there are several genera and species that are identical: Proteaceæ are common to both, so are several genera of Irideæ, Leguminosæ, Ficoideæ, Myrtaceæ, Diosmeæ, and some others. The botany of the Cape is connected with that of India, and even that of South America, by a few congeners.

The vegetation of Madagascar, though similar in many respects to the floras of India and Africa, nevertheless is its own: the Brexiaceæ and Chle-

naceæ are orders found nowhere else; there are species of Bignonia, Cycadeæ, and Zamias, a few of the mangosteen tribe, and in the mountains some heaths. The Hydrogeton fenestralis is a singular aquatic plant, with leaves like the dried skeletons of leaves, having no green fleshy substance, and the Tanghinia veneniflua, which produces a poison so deadly that its seeds are used to execute criminals, and one seed is sufficient.

Some genera and species are common and peculiar to Madagascar, the Isle of Bourbon, and Mauritius; yet of the 161 known genera in Madagascar only 54 grow on the other two islands. The three islands are rich in ferns. The Pandanus, or screw-pine genus, abounds in Bourbon and the Mauritius, where it covers sandy plains, sending off strong aërial roots from the stem, which strike into the ground and protect the plant from the violent winds. Of 290 genera in Bourbon and Mauritius, 196 also grow in India, though the species are different: there is also some resemblance to the vegetation of South Africa, and there is a solitary genus in common with America.

Eight or ten degrees north of Madagascar lies the group of the Seychelles Islands, in which are groves of the peculiar palm which bears the double cocoa-nut, or coco de mer, the growth of these islands only. Its gigantic leaves are employed in the construction of houses, and other parts of the plant are applied to various domestic purposes.

FLORA OF AUSTRALIA.

The interior of the Australian continent is so little known, that the flora which has come under observation is confined to a short distance from the coast; but it is of so strange and unexampled a character, that it might easily be mistaken for the production of another planet. Many entire orders of plants are known only in Australia, and the genera and species of others that grow elsewhere assume new and singular forms. Evergreens, with hard narrow leaves of a sombre, melancholy hue, are prevalent, and there are whole shadowless forests of leafless trees; the foot-stalks, dilated and set edgewise on the stem, supply their place and perform the functions of nutrition; their altered position gives them a singular appearance. Plants in other countries have glands on the under side of the leaves, but in Australia there are glands on both sides of these substitutes for leaves, which make them dull and lustreless, and the changes of the seasons have no influence on the unvarying olive-green of the Australian forests; even the grasses are distinguished from the gramineæ of other countries by a remarkable rigidity. Torres Straits, in the north, only 50 miles broad, separates this dry, sombre vegetation from the luxuriant jungle-clad shores of New Guinea, where deep and dark forests are rich in more than the usual tropical exuberance—a more complete and sudden change can hardly be imagined.

The peculiarly Australian vegetation is in the southern part of the continent of New Holland distributed in distinct foci in the same latitude, a circumstance of which the Proteaceæ afford a remarkable instance. Nearly one-half of the known species of these beautiful shrubs grow in the parallel of Port Jackson, from which they decrease in number both to the south and the north. In that latitude, however, there are twice as many species on the eastern side of the continent as there are on the western, and four times as many as in the centre. Although the Proteaceæ at both extremities of the continent have all the characters peculiar to Australia, yet those on the eastern coast resemble the South American species, while those on the western side have a resemblance to African forms, and are confined to the same latitudes.

Species of this family are numerous in Van Diemen's Land; where they thrive at the elevation of 3500 feet, and also on the plains. The myrtle tribe form a conspicuous feature in Australian vegetation, particularly the genera Eucalyptus, Melaleuca, Beaufortia, and others, with splendid blossoms—white, purple, yellow, crimson: 100 species of the Eucalypti, most of them large trees, grow in New Holland; they form great forests in the colony of Port Jackson. The leafless acacias, of which there are 93 species, are a prominent feature in the Australian landscape. The leaves, except in very young plants, are merely foliaceous foot-stalks, presenting their 'argin towards the stem; yet these and the Euca-

lypti form the densest shade of any trees in the country. The genus Casuarina, with its strange-jointed, drooping branches, called the marsh-oak, holds a conspicuous place; it is chiefly confined to the principal parallel of this vegetation, and produces excellent timber; it grows also in the Malayan peninsula and South Sea islands. The Oxleya xanthoxylon or yellow wood, one of the mahogany tribe, grows to great size, and the Podocarpus aspleniifolia forms a new genus of the cone-bearing trees. Some of the nettle tribe grow 15 or even 20 feet high. The Epacrideæ, with scarlet, rose, and white blossoms, supply the place of, and very much resemble, heaths, which do not exist here. The purple-flowering Tremandreæ; the yellow-flowering Dilleniaceæ; the Doryanthes excelsa, the most splendid of the lily tribe, 24 feet high, with a brilliant crimson blossom; the Banksia, the most Australian of all the Proteaceæ; with Zamias of new species, are all conspicuous in the vegetation of Port Jackson.

There is a change on the north-eastern coast of New Holland. The Castanospermum Australe is so plentiful that it furnishes the principal food of the natives; a caper-tree of grotesque form, having the colossal dimensions of the Senegal baobab, and extraordinary trees of the fig genus, characterize this region. It sometimes occurs, when the seeds of these fig-trees are deposited by birds on the iron-bark-tree, or Eucalyptus resinifera, that they vegetate and enclose the trunk of the tree entirely with their roots, whence they send off enormous lateral

branches, which so completely envelop the tree, that at last its top alone is visible in the centre of the fig-tree, at the height of 70 or 80 feet. The Pandanus genus flourishes within the influence of the sea-air. There are only six species of palms, equally local in their habitations as elsewhere, not one of which grows on the west side of the continent. The Araucaria excelsa, or Norfolk Island pine, produces the best timber of any tree in this part of Australia: it, or others of the same genus, extends from the parallel of 29° on the east coast towards the equator, and grows over an area of 900 square miles, including New Norfolk, New Caledonia, and other islands, some of which have no other timber-tree: they are supposed to exist only within the influence of the sea. The Asphodeleæ abound and extend to the southern extremity of Van Diemen's Land.

The south-western districts of New Holland exhibit another focus of vegetation, less rich in species than that of Port Jackson, but not less peculiar. The Kingia Australis, or grass-tree, rises solitary on the sandy plains, with bare blackened trunks as if scathed by lightning, occasioned by the fires of the natives, and tufts of long grassy leaves at their extremities; Banksias, particularly the kind called wild honeysuckle, are numerous; the Stylidium, whose blossoms are even more irritable than the leaves of the sensitive mimosa, and plants with dry, everlasting blossoms, characterize the flora of these districts. The greater part of the southern vegeta-

tion vanishes on the northern coasts of the continent, and what remains is mingled with the cabbage-palm, various species of the nutmeg tribe, sandal-wood, and other Malayan forms—a circumstance that may hereafter be of importance to our colonists.

Orchideæ, chiefly terrestrial, are in great variety in the extratropical regions of New Holland, and the grasses amount to one-fourth of the monocotyledonous plants. Reeds of gigantic size form forests in the marshes, and kangaroo-grass covers the plains.

Beautiful and varied as the flora is, New Holland is by no means luxuriant in vegetation. There is little appearance of verdure, the foliage is poor, the forests often shadeless, and the grass thin; but in many valleys of the mountains, and even on some parts of the plains, the vegetation is vigorous. It is not the least remarkable circumstance in this extraordinary flora, that, with the exception of a few berries, there is no edible fruit, grain, or vegetable indigenous either in New Holland or Van Diemen's Land.

The plants of New Holland prevail in every part of Van Diemen's Land; yet the coldness of the climate and the height of the mountains permit genera of the northern hemisphere to be mixed with the vegetation of the country. Butter-cups, anemones, and polygonums of peculiar species grow on the mountain-tops, together with Proteaceæ and other Australian plants. The plains glow with the warm golden flowers of the black wattle, a Mimosa, em-

blematic of the island, and with the equally bright and orange blossom of the gorse, which perfumes the whole atmosphere. Only one tree-fern grows in this country; it rises 20 feet to the base of the fronds, which spread into an elegant top, producing a shadow gloomy as night-fall, and there are 150 species of orchis. The southern extremities both of New Holland and Van Diemen's Land are characterised by the prevalence of evergreen plants: but the trees here, as well as in the other parts of the southern hemisphere, do not shed their leaves periodically as with us.

The botany of New Zealand appears to be intimately allied to that of New Holland, South America, and South Africa, but chiefly to that of New Holland. Noble trees form impenetrable forests, 60 of which yield the finest timber, and many are of kinds to which we have nothing similar. Here there are no representatives of our oak, birch, or willow, but five species of beech and ten of Coniferæ have been discovered that are peculiar to the country. They are all alpine, and only descend to the level of the sea in the southern parts of the island. The Coniferæ of the southern hemisphere are more local than in the northern; of the ten species peculiar to New Zealand it is not certain that more than two or three are found in the middle island, or that any of them grow south of the 40th parallel. The Kauri pine, or Dammara australis, is indigenous in all the three islands, but it is the only cone-bearing tree in North Island, where it grows in hilly situations near

the sea, shooting up with a clean stem 60 or 90 feet, sometimes 30 feet in diameter, with a spreading but thin top, and generally has a quantity of transparent yellow resin imbedded at its base. This fine tree does not grow beyond the 38th degree of S. lat. The Metrosideros tomentosa, with rich crimson blossoms, is one of the greatest ornaments of the forests, and the Metrosideros robusta the most singular. It grows to a very great size, and sends shoots from its trunk and branches to the ground, which become so massive that they support the old stem, which to all appearance loses its vitality; it is in fact an enormous epiphyte, growing to, and not from, the ground. Many of the smaller trees are of the laurel tribe, with poisonous berries. Besides, there is a cabbage-palm, the Areca sapida, elder, the Fuchsia excorticata, and other shrubs. This country is probably the southern limit of the orchideous plants that grow on trees. Before New Zealand was colonized, the natives lived chiefly on the roots of the edible fern, Pteris esculenta, with which the country is densely covered, mixed with a shrub that grows like a cypress, and the tea-plant, which is a kind of myrtle whose berries afford an intoxicating liquor. More than 140 species of fern are natives of these islands, some of which are arborescent and 40 feet high; the country is chiefly covered with these and with the New Zealand flax, Phormium tenax, which grows abundantly both on the mountains and plains. The vegetation is so vigorous on these volcanic islands that it grows richly on the banks

of hot springs, and even in water too hot to be touched.[1]

In Norfolk Island 152 species of plants are already known, and many, no doubt, are yet to be discovered. The Cape gooseberry or Physalis edulis, the guava-tree, pepper, white and swamp oak, iron, blood-wood, and lemon trees, are native; also the bread-fruit tree, which blossoms, but does not bear fruit. The Araucaria excelsa and some palms are indigenous, and there are three times as many ferns as of all the other plants together.

The multitude of islands of Polynesia constitute a botanical region apart from all others, though it is but little varied, and characterized principally by the number of syngenesious plants with arborescent terms and tree-ferns. In continental India and the tropical parts of New Holland the proportion of ferns to conspicuously flowering plants is as 1 to 26, while on the Polynesian islands it is as 1 to 4, and perhaps even as 1 to 3.[2]

The cocoa-nut palm and the pandanus are common to all the islands, but the latter thrives only when exposed to the sea-air. This archipelago produces Tacca pinnatifida, which yields arrow-root; the Morus papyrifera, whose bark is manufactured into paper; and one of the Dracæna tribe, from which an intoxicating liquor is made. Fifty varieties of the bread-fruit tree are indigenous, which produce three or four crops annually. It is most abundant in the Friendly, Society, and Caroline groups, from whence

[1] Dr. Mantel. [2] Dr. J. D. Hooker.

it has been taken to America, where it thrives in very low latitudes. The Sandwich group is peculiar in the number of Goodenias and Lobelias; while the Coral Islands, whose flora is entirely borrowed, rarely have two species belonging to the same genus; the fragrant suriana and sweet-scented Tournfortia are among their scanty vegetation.

The two species of banana-trees which are natives of southern Asia have been introduced at an unknown and probably early period into the Polynesian islands, and all tropical countries in the eastern and western hemispheres. Syria is their northern limit, where the Musa paradisaica grows to 34° N. lat. The sweet fruit of these trees produces, on the same extent of ground, 44 times as much nutriment as the potato, and 133 times more than wheat.

St. Helena, the Sandwich group, New Zealand, Juan Fernandez, and above all the Galapagos islands, are more peculiar in their floras than any other tracts of their size. The Galapagos archipelago consists of 10 principal islands lying immediately under the equator, 600 miles from the coast of America. They are entirely volcanic, and contain 2000 extinct craters. The vegetation is so peculiar that, of 180 plants which have been collected, 100 are found nowhere else; of 21 species of Compositæ all but one are new, and belong to 10 genera, 8 of which are confined to these islands exclusively.

This flora has no analogy to that of Polynesia, but it bears a double relation to the flora of South

America. The plants peculiar to the Galapagos islands are for the most part allied to those on the cooler part of the continent or on high lands, while the others are the same with those that abound in the hot damp intertropical regions of the continent. The greatest number of peculiar plants grow on the tops of the islands where the sea vapour is condensed, and many of them are confined to some one islet of the group. Though this flora is singular, it is poor compared with that of the Sandwich group, or the Cape de Verde Islands.[1]

[1] The Euphorbia and Borreria are the distinguishing features of the low grounds in the Galapagos islands; while the Scleria, croton, and Cordia mark the high grounds. Compositæ and Campanulaceæ distinguish St. Helena and Juan Fernandez. The prevailing plants in the Sandwich group are the Goodeniaceæ and Lobeliaceæ; and in New Zealand ferns and club-mosses prevail, almost to the exclusion of the grasses.—Dr. J. D. Hooker.

CHAPTER XXVII.

American Vegetation — Flora of North, Central, and South America — Antarctic Flora — Origin and Distribution of the Cerealia — Ages of Trees — Marine Vegetation.

FROM similarity of physical circumstances the arctic flora of America bears a strong resemblance to that of the northern regions of Europe and Asia. This botanical district comprises Greenland, and extends considerably to the south of the arctic circle, especially at the eastern and western ends of the continent, where it reaches the 60th parallel of N. lat., and even more; it is continued along the tops of the Rocky Mountains almost to Mexico, and it re-appears on the White Mountains and a few other parts of the Alleghannies.

Greenland has a much more arctic flora than Iceland; the valleys are entirely covered with mosses and marsh-plants, and the gloomy rocks are cased in sombre lichens that grow under the snow, and the grasses on the pasture-grounds that line the fiords are nearly four times less varied than those of Iceland. In some sheltered spots the service-tree bears fruit, and birches grow to the height of a few feet: but ligneous plants in general trail on the ground.

The arctic flora of America has much the same character with that of Europe and Asia, and many species are common to all; still more are representative, but there is a difference in the vegetation

at the two extremities of the continent; there are 30 species in the east and 20 in the west end which grow nowhere else. The sameness of character changes with the barren treeless lands at the verge of the Arctic region, and the distribution of plants varies both with the latitude and the longitude. Taking a broad view of the botanical districts of North America, there are two woody regions, one on the eastern, the other on the western side of the continent, separated by a region of prairies where grasses and herbaceous plants predominate. The vegetation of these three parts, so dissimilar, varies with the latitude, but not after the same law as in Europe, for the winter is much colder and the summer warmer on the eastern coasts of America than on the western coast of Europe, owing in a great measure to the prevalence of westerly winds which bring cold and damp to our shores.

Boundless forests of black and white spruce, with an undergrowth of reindeer moss, cover the country south of the Arctic region, which are afterwards mixed with other trees; gooseberries, strawberries, currants, and some other plants thrive there. There are vast forests in Canada of pines, oak, ash, hicory, red beech, birch, the lofty Canadian poplar, sometimes 100 feet high and 36 feet in circumference, and sugar-maple; the prevailing plants are Kalmias, azaleas, and asters, the former vernal, the latter autumnal; solidagos and asters are the most characteristic plants of this region.

The splendour of the North American flora is dis-

played in the United States; the American sycamore, chestnut, black walnut, hicory, white cedar, wild cherry, red birch, locust-tree, tulip-tree, or Liriodendron, the glory of American forests, liquidambar, oak, ash, pine-trees of many species, grow luxuriantly, with an undergrowth of rhododendrons, azaleas, Andromedas, Gerardias, Calycanthus, Hydrangea, and many more of woody texture, with an infinite variety of herbàceous and climbing plants.

The vegetation is different on the two sides of the Alleghanny mountains; the locust-tree, Canadian poplar, Hibiscus, and Hydrangea, are most common on the west side; the American chestnut and Kalmias are so numerous on the Atlantic side as to give a distinctive character to the flora: here, too, aquatic plants are more frequent; among these the Sarracenia or side-saddle flower, singular in form, with leaves like pitchers covered with a lid, half full of water.

The autumnal tints of the forests in the middle States are beautiful and of endless variety; the dark leaves of the evergreen pine, the red foliage of the maple, the yellow beech, the scarlet oak, and purple Nyssa, with all their intermediate tints, ever changing with the light and distance, produce an effect at sunset that would astonish the native of a country with a more sober-coloured flora under a more cloudy sky.

In Virginia, Kentucky, and the southern States the vegetation assumes a different aspect, though many plants of more northern districts are mixed with it. Trees and shrubs here are remarkable for

broad shining leaves and splendid blossoms, as the Gleditschia, Catalpa, Hibiscus, and all the family of Magnolias, which are natives of the country, excepting a very few found in Asia and the Indian islands. They are the distinguishing feature of the flora from Virginia to the Gulf of Mexico, and from the Atlantic to the Rocky Mountains: the Magnolia grandiflora and the tulip-tree are the most splendid specimens of this race of plants; the latter is often 120 feet high. The long-leaved pitch-pine, one of the most picturesque of trees, covers an arid soil on the coast of the Atlantic of 60,000 square miles. The swamps so common in the southern States are clothed with gigantic deciduous cypress, the aquatic oak, swampy hicory, with the magnificent Nelumbium luteum and other aquatics, and among the innumerable herbaceous plants the singular Dionæa muscipula, or American fly-trap: the trap is formed by two opposite lobes of the leaf, covered with spines, and so irritable, that they instantly close upon the insect that has come to light upon them. This Magnolia region corresponds in latitude with the southern shores of the Mediterranean, but the climate is hotter and more humid, in consequence of which there is a considerable number of Mexican plants. A few dwarf-palms appear among the Magnolias, and the forests in Florida and Alabama are covered with Tillandsia usneoides, an air-plant, which hangs from the boughs.[1]

[1] Of 2891 species of flower-bearing plants in the United States of North America, there are 385 found also in northern and temperate Europe.

Ten or twelve species of grass cover the extensive prairies or steppes of the valley of the Mississippi. The forms of the Tartarian steppes appear to the north in the Centaurea, Artemisia, Astragali; but the Dahlias, Œnotheras, with many more, are their own. The Helianthus and Coreopsis, mixed with some European genera, mark the middle regions; and in the south, towards the Rocky Mountains, Clarkia and Bartonia are mixed with the Mexican genera of Cactus and Yucca. The western forest is less extensive and less varied than the eastern, but the trees are larger. This flora in high latitudes is but little known; the Thuia gigantea on the Rocky Mountains and the coast of the Pacific is 200 feet high. Claytonias and currants, with plants of northern Asia, are found here.

Farther west the Pinus Lambertiana is another specimen of the stupendous trees of this flora; seven species of pine are indigenous in California, some of which have measured 200, and even 300 feet high, and 80 in circumference. Captain Sir Edward Belcher, in his 'Voyage on the Pacific,' mentions having measured an oak 27 feet in circumference, and another 18 feet girth at the height of 60 feet from the ground, before the branches began to spread. This is the native soil of the currant-bushes with red and yellow blossoms, of many varieties of lupins, pæonies, poppies, and other herbaceous plants so ornamental in our gardens.

There are 332 genera of plants peculiar to North America, exclusive of Mexico, but no family of any

great extent has yet been discovered there. About 160 large trees yield excellent timber; the wood of the pine-trees of the eastern forests is of inferior quality to that grown on the other side of the continent, and both appear to be less valuable than the pine-wood of Europe, which is best when produced in a cold climate. The Pinus Cembra and the Pinus uncinata are the most esteemed of the Old World.

The native fruits of North America are mostly of the nut-kind, and there are many of these, to which may be added the Florida orange, the chicasa plum, the papaw, the banana, the red mulberry, and the plumlike fruit of the persimon. There are seven species of wild grapes, but good wine has not hitherto been produced. Although America has contributed so much to the ornament of our pleasure-grounds and gardens, yet there are comparatively few North American plants which have become an object of extensive cultivation, while America has borrowed largely from other parts of the globe; the grapes cultivated in North America are European; tobacco, Indian corn, and many others of the utmost commercial value are strangers to the soil, having been introduced by the earliest inhabitants from Mexico and South America, which have contributed much more to general utility.

FLORA OF MEXICO AND THE WEST INDIES.

Mexico itself unites the vegetation of North and South America, though it resembles that of the lat-

ter more nearly. Whole provinces on the table-land and mountains produce alpine plants, oaks, chestnuts, and pines spontaneously. The Cheirostemon, or hand-tree, so named from the resemblance its stigma bears to the human hand, grows here, and also in the Guatimala forests.

The low lands of Mexico and Central America have a very rich flora, consisting of many orders and genera peculiar to them, and species without number, a great portion of which are unknown. The Hymenea Courbaril, from which the copal of Mexico is obtained, logwood, mahogany, and many other large trees, valuable for their timber, grow in the forests; sugar-cane, tobacco, indigo, American aloe, yam, capsicum, and yucca are indigenous in Mexico and Central America. It is the native region of the Melastomas, of which 620 species are known; almost all the pepper tribe, the Passifloræ, the ornament and pride of tropical America and the West Indian islands, begin to be numerous in these regions. The pine-apple is entirely American, growing in the woods and savannahs: it has been carried to the West Indies, to the East Indies and China, and is naturalized in all. This country has also produced the cherimoya, said to be the most exquisite of fruits. All the vanilla that is used in Europe comes from the states of Vera Cruz and Oaxaca, on the eastern slopes of the Cordillera of Anahuac in Mexico. It is native throughout tropical America, growing in hot, damp, shady places. Hot arid tracts are covered with the Cactus tribe, a family of Central America

and Mexico, which is more widely dispersed than the anana: some species bear a considerable degree of cold. They are social plants, inhabiting sandy plains in thickets, and of many species: their forms are various, and their blossoms beautiful. A few occur at a considerable distance from the tropics, to the north and the south. The night-flowering Cereus grows in all its beauty in the arid parts of Chile, filling the night air with its perfume. The Cactus opuntia grows in the Rocky Mountains; and Sir George Back found a small island in the Lake of the Woods covered with it. This species has been brought to Europe, and now grows a common weed on the borders of the Mediterranean. In Mexico the cochineal insect was collected from the Cactus coccinellifer long before the Spanish conquest. There are large fields of American aloe, from which a liquor called pulque, and also an ardent spirit, are made. The ancient Mexicans made their hemp from this plant, and also their paper. The forests of Panama contain at least 97 different kinds of trees, which grow luxuriantly in a climate where the torrents of rain are so favourable to vegetation, and so unfavourable to life that the tainted air is deadly even to animals.

The sugar-cane is a native of both continents; Columbus found it wild in many parts of America: the sweet cane is mentioned by the Prophets, and it has grown time immemorial on the coasts of China and in the islands of the Pacific. Its culture ranges throughout the torrid zone, and to

latitudes where the mean temperature is not under 64° of Fahrenheit. It grows on the plains of Nepaul at an absolute elevation of 4800 feet, and at the height of from 3500 to 5100 feet in the Cordillera of New Granada. It is now scarcely cultivated in the southern provinces of New Spain, where it was introduced by the Spaniards, but it is extensively raised in Guiana, Brazil, the West India islands, the Mauritius, Bourbon, Bengal, Siam, Java, the Philippine islands, and China.

Maize or Indian corn is believed to have come originally from Mexico and South America. It is an annual, requiring only summer heat; its limit is 50° N. in the American continent, and 47° N. in Europe; it ripens at an elevation of 7600 feet in low latitudes, and in the Lower Pyrenees at the height of 3289 feet.[1]

The flora of each West Indian island is similar to that of the continent opposite to it. The Myrtus pimento, producing allspice, is common in the hills; custard-apple, guava, the avocado pear, and tobacco are indigenous; the cabbage-palm grows to the height of 150 feet; the palma-real of Cuba is the most majestic of that noble family; and in Barbadoes there still exists a tree, but wearing out rapidly, which has given the island its name.

[1] In the basin of Titicaca in Peru-Bolivia, Mr. Pentland has seen a variety of maize ripen as high as 12,800 feet.

FLORA OF TROPICAL AMERICA.

Although the flora of tropical America is better explored than that of Asia or Africa, there must still be thousands of plants of which we have no knowledge; and those which have come under observation are so varied and so numerous, that it is not possible to convey an idea of the peculiarities of this vegetation, or of the extent and richness of its woodlands. The upper Orinoco flows for some hundred miles chiefly through forests; and the silvas of the Amazons are six times the size of France. In these the trees are colossal, and the vegetation so matted together by underwood, creeping and parasitical plants, that the sun's rays can scarcely penetrate the dense foliage.

These extensive forests are by no means uniform; they differ on each side of the equator, though climate and other circumstances are the same. Venezuela, Guiana, the Amazona, and Brazil, are each the centre of a peculiar flora. So partial is this splendid vegetation, that almost each tributary of the great rivers has a flora of its own: particular families of plants are so restricted in their localities, and predominate so exclusively where they occur, that they change the appearance of the forest. Thus, from the prevalence of the orders Laurineæ, Sapotaceæ, and others, which have leathery, shining, and entire leaves, the forests through which the Rio Negro, Cassiquiare, and Tuamine flow, differ in

aspect from those of the other affluents of the Amazons. Even the grassy llanos, so uniform in appearance, have their centres of vegetation; and only agree with the pampas of Buenos Ayres in being covered with grass and herbs. In these tropical regions the flora varies with the altitude also. On the Andes, almost at the limit of vegetation, the ground is covered with purple, azure, and scarlet gentians, drabas, alchemillas, and many other brilliantly coloured alpine plants. This zone is followed by thickets of coriaceous-leaved plants, in perpetual bloom and verdure; and then come the forest-trees. Arborescent ferns ascend to 7000 feet; the coffee-tree and palms to 5000; and neither indigo nor cocoa can be cultivated lower than 2000. The tree yielding cocoa, of which chocolate is made, grows wild in Guiana, Mexico, and on the coast of the Caraccas; it is now cultivated in Central and South America, even to Chile, also in the Canary and Philippine islands, into which it was introduced by the Spaniards. The seeds of its fruit, which is like a cucumber, are the cocoa.

Many parts of the coasts of Venezuela and Guiana are rendered pestilential by the effluvia of the mangrove, Avicennia, and the manchineel, one of the Euphorbia family, consisting of 562 species in tropical America, all having milky juice, deleterious in the greater number. The well-known poison Ourari is prepared by the Indians of Guiana from the fruit and bark of the Strychnos toxicaria, than which nature has probably produced no plants more deadly.

This Ourari (or Wourali) is a creeping plant which yields the deadly juice, the powerful effect of which was proved by Mr. Waterton's experiments.

The Cinchona, or true bark-tree, grows only on the Cordilleras of the Andes.[1] Some of its medicinal qualities are found in other plants of different genera in Guiana, as the Cusparia carony, which produces the Angostura bark. The Sapindus saponaria, or soap-tree, is used by the natives for washing. Capsicum, vanilla, the incense-plant, the Dipteryx odorata, whose fruit is the tonquin-bean, and the cassava or mandioc, are natives of the country. There are two kinds of mandioc, a shrub whose fleshy roots yield a farina eaten by the natives of Spanish America and Brazil: the root of one is harmless, but the other contains a poisonous milky juice, the effects of which are removed by cultivation or pressure. It grows to about 30° on each side of the equator, and to 3200 feet above the sea-level. An acre of mandioc is said to yield as much nourishment as six acres of wheat.

Arrow-root is native in South America; it has been transported to the West Indies and Ceylon. The flour is the produce of the root. The plant is said to owe its name to the belief of its being an antidote

[1] Dr. Weddell, a very distinguished botanist, who has recently returned from an exploration of the districts of the Andes which furnish the Peruvian bark of commerce, has discovered several new species of Cinchona, the total number of which, according to his beautiful monography, now amounts to 21

to the poison of the arrows of the Indians. The cow-tree, almost confined to the Cordillera of the coast of Venezuela, yields such abundance of nutritious milky juice that it is carried in gourds, like milk from the cow. The chocolate-plant, or cacao-shrub, fruits of the most excellent flavour, plants yielding balsam, resin, and gum, are numerous in the tropical regions. There the laurel tribe assume the character of majestic trees: some are so rich in oil, that it gushes from a wound in the bark. One of these laurels produces the essential oil which dissolves caoutchouc, or Indian rubber, used in rendering cloth waterproof.

Plantains of gigantic size form large forests; but palms are the most numerous and the most beautiful of all the trees in these countries. There are 90 species of them; and they are so local that a change takes place every 50 miles. They are the greatest ornament of the upper Orinoco.

The llanos of Venezuela and Guiana are covered with tall grass, mixed with lilies and other bulbous flowers, sensitive mimosas, and palms constantly varying in species.

No language can describe the glory of the forests of the Amazon and Brazil, the endless variety of form, the contrasts of colour and size: there even the largest trees bear brilliant blossoms; scarlet, purple, blue, rose-colour, and golden yellow, are blended with every possible shade of green. Majestic trees, as the Bombax ceiba (or silk-cotton tree), the dark-leaved mora with its white blossoms, the

fig, cashew, and mimosa tribes, which are here of unwonted dimensions, and a thousand other giants of the forest, are contrasted with the graceful palm, the delicate Acacia, reeds of 100 feet high, grasses of 40, and tree-ferns in myriads. Passifloræ and slender creepers twine round the lower plants, while others as thick as cables climb the lofty trees, drop again to the ground, rise anew and stretch from bough to bough, wreathed with their own leaves and flowers, yet intermixed with the vividly coloured blossoms of the Orchideæ. An impenetrable and everlasting vegetation covers the ground; decay and death are concealed by the exuberance of life; the trees are loaded with parasites while alive—they become masses of living plants when they die.

One twenty-ninth part of the flowering plants of the Brazilian forests are of the coffee tribe, and the rose-coloured and yellow-flowering bignonias are among their greatest ornaments, where all is grace and beauty. Thousands of herbs and trees must still be undescribed where each stream has its own vegetation. The palm-trees are the glory of the forest: 81 species of these plants are natives of the intertropical parts of Brazil alone; they are of all sizes, from such as have hardly any stem to those that rise 130 feet.[1] In those parts of Brazil less favoured by nature the forests consist of stunted deciduous trees,

[1] Professor Martius, of Munich, in his great work on Palms, has described 500, accompanied with excellent coloured plates. It is supposed that the number of species throughout the world amounts to 1000.

and the boundless plains have grasses, interspersed with myrtles and other shrubs.[1]

The forests on the banks of the Paraguay and Vermejo are almost as rich as those of the tropics. Noble trees furnish timber and fruit; the algaroba, a kind of acacia, produces clusters of a bean, of which the Indians make bread, and also a strong fermented liquor; the palm and cinchona grow there; and the yerba-maté, the leaves of which are universally used as tea in South America, and were in use before the Spanish conquest. It is a species of holly, with leaves five or six inches long.

The sandy deserts towards the mountains are the land of the Agave and Cactus in all their varieties. The fibres of the Agave are made into cordage by the Indians for fishing-nets and other uses, and the juice affords them drink. Some larger species of Cactus give a light and durable wood; and the cochineal insect, which feeds on them, is a valuable article of commerce.

Grass, clover, and European and African thistles, which have been introduced, with a solitary Ombu at wide intervals, are the unvarying features of the pampas; and thorny stunted bushes, characteristic of all deserts, are the only vegetation of the Patagonian shingle. But on the mountain valleys in the far south may be seen the winter's-bark, arbutus, new

[1] There are innumerable points of analogy between the vegetation of the Brazils, equinoctial Africa, and India: but the number of species common to these three continents is very small.

species of beech-trees, stunted berberries, and Misodendron, which latter is a singular kind of parasitical plant.

Large forests of Araucaria imbricata grow in the Andes of Chile and Patagonia. This tall and handsome pine, with cones the size of a child's head, supplies the natives with a great part of their food. It is said that the fruit of one large tree will maintain eighteen persons for a year.

Nothing grows under these great forests; and when accidentally burnt down in the mountainous parts of Patagonia, they never rise again, but the ground they grew on is soon covered with an impenetrable brushwood of other plants. In Chile the violently stinging Loasa appears first in these burnt places, bushes grow afterwards, and then comes a tree-grass, 18 feet high, of which the Indians make their huts. The new vegetation that follows the burning of primeval forests is quite unaccountable. The ancient and undisturbed forests of Pennsylvania have no undergrowth, and when burnt down they are succeeded by a thick growth of rhododendrons.

The southern coasts of Chile are very barren, and all plants existing there, even the herbaceous, have a tendency to assume a hard knotty texture. The stem of the wild potato, which is indigenous in Chile and Peru, becomes woody and bristly as it grows old. It is a native of the sea-strand, and is never found naturally more than 400 feet above it. In its wild state the root is small and bitter; it is one of many

instances of the influence of cultivation in rendering unpromising plants useful to man.

It was cultivated in America at the time of its discovery, and is so now, at the height of from 9800 to 13,000 feet above the sea on the Andes, and as high as 4800 feet on the Swiss Alps; it does not succeed on the plains in hot countries, nor farther north than Iceland. It had been introduced into Europe by the Spaniards before the time of Sir Walter Raleigh; he brought it to England from Virginia in 1586.

Coca, the Erythroxylon Coca of botanists, is a native of the tropical valleys on the eastern declivity of the Andes of Peru and Bolivia, where it is extensively cultivated for its leaf, of which the tree furnishes 3 or 4 crops annually; the coca-leaf, which possesses nutritive and narcotic qualities, is chewed by the aborigines mixed with an alcaline substance: it allays hunger and enables the Indian to undergo great fatigue without any other nourishment for days together; it is an article of great trade, and absolutely indispensable in the more laborious profession of the miner.

Between the southern parallels of 38° and 45° Chile is covered with extensive forests. Stately trees of many kinds, having smooth and brightly-coloured trunks, are bound together by parasitical plants of the monocotyledonous structure; large and elegant ferns are numerous, and arborescent grasses entwine the trees to the height of 20 or 30 feet; palm-trees grow to the 37th parallel of latitude, their southern limit.

Although the flora, at an elevation of 9000 feet on the Chilian Andes, is almost identical with that of the Straits of Magellan, yet the climate is so mild in some valleys, especially that of Antuco, that the vegetation is semi-tropical. In it broad-leaved and bright-coloured plants, and the most fragrant and brilliant Orchideæ, are mixed with the usual alpine genera. Dr. Poeppig says, that whatever South Africa or New Holland can boast of in beauty, in variety of form, or brilliancy of colour, is rivalled by the flora in the highest zone in this part of the Andes, even up to the region of perpetual snow; and, indeed, it bears a strong analogy to the vegetation of both these countries.

The Andes so completely check the migration of plants, that almost throughout their whole length there is no mingling of the floras on their east and west sides, except at the Isthmus of Panama, where the mahogany-tree crosses from the Atlantic to the Pacific side, and in the same way many of the plants on the lands on the east are brought to the west, and spread to California on one side, and as far as the dry plains of Peru on the other.[1]

The humidity or dryness of the prevailing winds makes an immense difference in the character of the countries on each side of the Andes. Within the southern tropic the trade-winds come loaded with vapour from the Atlantic, which is partly precipitated by the mountains of Brazil, and supplies the noble forests of that country with never-ceasing moisture,

[1] Dr. J. D. Hooker.

while the remainder is condensed by the Andes, so that on their eastern side there is an exuberant vegetation, while on the western declivities and in the space which separates them from the Pacific they are almost barren, and on the plains and in the valleys of Peru, where rain very seldom falls, completely so, except where artificial irrigation is employed. Even on the eastern side of these mountains the richness of the vegetation gradually disappears with the increasing height, till at an elevation of about 15,000 feet arborescent plants vanish, and alpine races, of the most vivid beauty, succeed; which, in their turn, give place to the grasses at the height of 16,138 feet. Above these, in the dreary plains of Bombon, and other lands of the same altitude, even the thinly-scattered mosses are sickly; and at the height of 21,878 feet the snow-lichen forms the last show of vegetable life; confirming the observation of Don Ulloa, that the produce of the soil is the thermometer of Peru.

ANTARCTIC FLORA.

Tierra del Fuego and Kerguelen's Land are the northern boundary of the antarctic lands, which are scattered round the south pole at immense distances from one another. On these the vegetation decreases as the latitude increases, till at length utter desolation prevails; not a lichen covers the dreary storm-beaten rocks; and, with the exception of a microscopic marine plant, not a sea-weed lives in the gelid waves. In the arctic regions, on the contrary, no

land has yet been discovered that is entirely destitute of vegetable life. This remarkable difference does not so much depend on a greater degree of cold in winter as on the want of warmth in summer. In the high northern latitudes the power of the summer sun is so great as to melt the pitch between the planks of the vessels; while in corresponding southern latitudes Fahrenheit's thermometer does not rise above 14° at noon at a season corresponding to our August. The perpetual snow comes to a much lower latitude in the southern lands than it does in the north. Sandwich Land, in a latitude corresponding to that of the north of Scotland, is perpetually covered with many fathoms of snow. A single species of grass, the Aira antarctica, is the only flowering plant in the South Shetland islands, which are no less ice-bound; and Cockburn Island, one of that group, in the 60th parallel, contains the last vestiges of vegetation; while the Namesake islands, in an equally high latitude, to the north of Scotland, are inhabited and cultivated; nay, South Georgia, in a latitude similar to that of Yorkshire, is always clad in frozen snow, and only produces some mosses, lichens, and wild burnet; while Iceland, 10 degrees nearer the pole, has 870 species, more than half of which are flower-bearing.

The forest-covered islands of Tierra del Fuego are only 360 miles from the desolate Shetland group. Such is the difference that a few degrees of latitude can produce in these antarctic regions, combined with an equable climate and excessive humidity.

: prevalence of evergreen plants is the most cha-
eristic feature in the Fuegian flora. Densely
ıngled forests of winter's bark, and two species of
ch-trees, grow from the shore to a considerable
ght on the mountains. Of these, the Fagus betu-
les, which never loses its brownish-green leaves,
vails almost to the exclusion of the evergreen
ıter's bark and the deciduous beech, which is very
.utiful. There are dwarf species of Arbutus, the
rtus nummularia, which is used instead of tea,
ides berberry, currant, and fuchsia; peculiar spe-
s of Ranunculi, calceolarias, Caryophylleæ, cru-
orm plants, and violets. Wild celery and scurvy-
ıss are the only edible plants; and a bright yellow
ıgus, which grows on the beech-trees, forms a
eat part of the food of the natives. There is a
eater number of plants in Tierra del Fuego, either
entical with those in Great Britain, or representa-
'es of them, than exists in any other country in
e southern hemisphere. The sea-pink, or thrift,
e common sloewort, a primula farinosa, and at
ast 30 other flowering plants, with almost all the
chens, 48 mosses, and many other plants of the
ptogamous kinds, are identically the same; while
.e number of genera common to both countries
still greater, and, though unknown in the inter-
ediate latitudes, reappear here. Hermite Island,
est from Cape Horn, is a forest-land, covered
ith winter's bark and the Fuegian beeches; and
the most southern spot on earth on which
borescent vegetation is found. An alpine flora,

many of the species of European genera, grows on the mountains, succeeded higher up by mosses and lichens. Mosses are exceedingly plentiful throughout Fuegia; but they abound in Hermite Island more than in any other country, and are of singular and beautiful kinds.

Although the Falkland Islands are in a lower latitude than Tierra del Fuego, not a tree is to be seen. The Veronica elliptica, resembling a myrtle, which is extremely rare and confined to West Falkland, is the only large shrub; a white-flowering plant like the aster, about four feet high, is common; while a bramble, a crowberry, and a myrtle, bearing no resemblance, however, to the European species, trail on the ground, and afford edible fruit. The balsam bog, or Bolax globaria, and grasses, form the only conspicuous feature in the botany of these islands; and, together with rushes and Dactylis cæspitosa, or Tussack grass, cover them, almost to the exclusion of other plants. The Bolax grows in tufted hemispherical masses, of a yellow-green colour, and very firm substance, often four feet high, and as many in diameter, from whence a strong-smelling resinous substance exudes, perceptible at a distance. This plant has umbelliferous flowers, and belongs to the carrot order, but forms an antarctic genus quite peculiar.

The Tussack grass is the most useful and the most singular plant in this flora. It covers all the small islands of the group, like a forest of miniature palm-trees, and thrives best on the shores exposed to the

spray of the sea. Each tussack is an isolated plant, occupying about two square yards of ground. It forms a hillock of matted roots, rising straight and solitary out of the soil, often six feet high and four or five in diameter ; from the top of which it throws out a thick grassy foliage of blades, six feet long, drooping on all sides, and forming with the leaves of the adjacent plants an arch over the ground beneath, which yields shelter to sea-lions, penguins, and petrels. Cattle are exceedingly fond of this grass, which yields annually a much greater supply of excellent fodder than the same extent of ground would do either of common grass or clover. Both the Tussack-grass and the Bolax are found, though sparingly, in Tierra del Fuego; indeed, the vegetation of the Falkland Islands consists chiefly of the mountain plants of that country, and of those that grow on the arid plains of Patagonia; but it is kept close to the ground by the fierceness of the terrific gales that sweep over these antarctic islands. Peculiar species of European genera are found here, as a calceolaria, wood sorrel, and a yellow violet; while the shepherd's purse, cardamine hirsuta, and the primula farinosa, appear to be identical with those at home. In all there are scarcely 120 flowering plants, including grasses. Ferns and mosses are few, but lichens are in great variety and abundance, among which many are identical with those in Britain.

In the same hemisphere, far, far removed from the Falkland group, the Auckland Islands lie in the

boisterous ocean south of New Zealand. They are covered with dense and all but impenetrable thickets of stunted trees, or rather shrubs, about 20 or 30 feet high, gnarled by gales from a stormy sea. There is nothing analogous to these shrubs in the northern hemisphere; but the Veronica elliptica, a native of Tierra del Fuego and New Zealand, is one of them. Fifteen species of ferns find shelter under these trees, and their fallen trunks are covered with mosses and lichens. Eighty flowering plants were found during the stay of the discovery ships, of which 56 are new; and half of the whole number are peculiar to this group and to Campbell's Island. Some of the most beautiful flowers grow on the mountains, others are mixed with the ferns in the forests. A beautiful plant was discovered, like a purple aster, a Veronica, with large spikes of ultramarine colour; a white one, with a perfume like jessamine; a sweet-smelling alpine Hierochloe; and in some of the valleys the fragrant and bright-yellow blossoms of a species of asphodel were so abundant that the ground looked like a carpet of gold. A singular plant grows on the sea-shore, having bunches of green waxy blossoms the size of a child's head. There are also antarctic species of European genera, as beautiful red and white gentians, geraniums, &c. The vegetation is characterized by an exuberance of the finer flowering plants, and an absence of grasses and sedges; but the landscape, though picturesque, has a sombre aspect, from the prevalence of brownish-leaved plants of the myrtle tribe.

Campbell's Island lies 120 miles to the south of the Auckland group, and is much smaller, but from the more varied form of its surface it is supposed to produce as many species of plants. During the two days the discovery ships, under the command of Sir James Ross, remained there, between 200 and 300 were collected, of which 66 were flowering plants, 14 of which were peculiar to the country. Many of the Auckland Island plants were found here, yet a great change had taken place; 34 species had disappeared and were replaced by 20 new, all peculiar to Campbell's Island alone, and some were found that hitherto had been supposed to belong to Antarctic America only. In the Auckland group only one-seventh of the plants are common to other Antarctic lands, whilst in Campbell's Island a fourth are natives of other longitudes in the Antarctic Ocean. The flora of Campbell's Island and the Auckland group is so intimately allied to that of New Zealand, that it may be regarded as the continuation of the latter, under an Antarctic character, though destitute of the beech and pine trees. There is a considerable number of Fuegian plants in the islands under consideration, though 4000 miles distant; and whenever their flora differs in the smaller plants from that of New Zealand, it approximates to that of Antarctic America: but the trees and shrubs are entirely dissimilar. The relation between this vegetation and that of the northern regions is but slight. The Auckland group and Campbell's Island are in a latitude corresponding to that of England,

yet only three indigenous plants of our island have been found in them, namely, the Cardamine hirsuta, Montia, and Callitriche. This is the utmost southern limit of tree-ferns.

Perhaps no spot in either hemisphere, at the same distance from the pole, is more barren than Kerguelen Islands, lying in a remote part of the south polar ocean. Only 18 species of flowering plants were found there, which is less than the number in Melville Island, in the Arctic Seas, and three times less than the number even in Spitzbergen. The whole known vegetation of these islands only amounts to 150, including sea-weeds. The Pringlea, a kind of cabbage, acceptable to those who have been long at sea, is peculiar to the island, and grass, together with a plant similar to the Bolax of the Falkland Islands, covers large tracts. About 20 mosses, lichens, &c., are only found in these islands, but many of the others are also native in the European Alps and north polar regions. It is a very remarkable circumstance in the distribution of plants, that there should be so much analogy between the floras of places so far apart as Kerguelen Islands, the groups south from New Zealand, the Falkland Islands, South Georgia, and Tierra del Fuego.

ORIGIN AND DISTRIBUTION OF CEREALIA.

The plants which the earth produces spontaneously are thus confined within certain districts, and few of them would survive a change of circumstances;

nevertheless Providence has endowed those most essential to man with a greater flexibility of structure, so that the limits of their production can be extended by culture beyond what have been assigned to them by nature. The grasses yielding the grains are especially favoured in this respect, though their extension depends upon the knowledge and industry of man; no grain will be cultivated where it can be procured from a foreign market at less expense; so that with regard to useful plants there is an artificial as well as a natural boundary. The cultivation of plants in gardens and hot-houses is entirely artificial and depends on luxury and fashion.

Tartary and Persia are presumed to have been the original countries of wheat, rye, and oats; but these grains have been so long in use that it is impossible to trace their origin with certainty. Barley grows spontaneously in Tartary and Sicily, probably of different species. Those plants which produce the grains must have had a more extended location than any other, and they can endure the greatest extremes of heat and cold. In high northern latitudes wheat is protected from the inclemency of winter by sowing it in spring, or if sown in autumn a coating of snow defends it: the polar limit is the isothermal line of 57° 2′, and wheat will not form seed within less than 20° or 23° of the equator. In America the northern limit is unknown, the country being uninhabited; but at Cumberland House, in the very middle of the continent, one of the stations of the Hudson's Bay Company, in 54° N. lat., there are

fields of wheat, barley, and maize. Wheat thrives luxuriantly in Chile and Rio de la Plata, and at elevations of 8500 and 10,000 feet above the sea. It even produces grain on the banks of the Lake Titicaca in the Peru-Bolivian Andes at the absolute height of 12,795 feet in sheltered situations, and good crops of barley are raised in that elevated region.

Barley bears cold better than any of the grains, yet neither it nor any other will grow in Iceland. It is successfully cultivated in the Feroe Islands, near Cape North, the extreme point of Norway, near Archangel on the White Sea, and in Central Siberia to between 58° and 59° N. lat.

Rye is only cultivated where the soil is very poor, and agriculture little understood, yet a third of the population of Europe lives on rye-bread, chiefly inhabitants of the middle and especially of the northern parts: its limit is about the 67th parallel of N. latitude.

Oats are scarcely known in middle and southern Europe; in the north they are extensively cultivated to the 65th degree of N. latitude.

Rice is the food of a greater number of human beings than any other grain: it has been cultivated from such high antiquity that all traces of its origin are lost. It contains a greater proportion of nutritious matter than any of the Cerealia, but, since it requires excessive moisture, and a temperature of 73° 4′ at least, its cultivation is limited to countries between the equator and the 45th parallel.

Indian corn and millet are much cultivated in

Europe south of the 45th and 47th parallels, and form an important article of food in France, Italy, Africa, India, and America. Buck-wheat is extensively cultivated in northern Europe and Siberia and the table-lands of central Asia; it is a native of Asia, from whence it was brought into Europe in the 15th century.

The cerealia afford one of the most remarkable examples of numberless varieties arising from the seed of one species. In Ceylon alone there are 160 varieties of rice, and at least 30 of Panicum. The endless varieties which may be raised from the seed of one plant is most conspicuous in the flower-garden: the rose affords above 1400; the varieties of the pansy, calceolaria, tulip, auricula, and primrose are without end, and often differ so much from the parent plant that it seems almost impossible they should have had a common origin: it seems difficult to believe that red cabbage, cauliflower, and many others should have sprung from the sea-kale or Brassica oleracea, so totally dissimilar from any of them, with its bitter sea-green curly leaves. Fashion changes so much with regard to plants that it is scarcely possible to form even an approximation to the number known to be in cultivation: new plants are introduced from a foreign country, and are apt to take the place of some of the older, which are neglected and sometimes lost; of 120,000 plants which are known to exist on the earth, not more than 15,000 are believed to be in cultivation.

It is supposed that plants capable of bearing a

great range of temperature would exist through longer geological periods than those more limited in their endurance of vicissitudes of temperature, and it appears that in many instances at least the existence of varieties depends on the life of the plant from whence they originated; the actual duration of individuals is a subject which has not been sufficiently studied, though the progress of physiological botany has given the means of doing so without destroying the plant.

Since forest-trees increase by coatings from without, the growth of each year forming a concentric circle of wood round the pith or centre of the stem, the age of a tree may be ascertained by counting the number of rings in a transverse section of the trunk, each ring representing a year. Moreover, the progress of the growth is known by comparing the breadth of the rings, which are broader in a favourable than in an unfavourable season, though this may depend also in some measure on the quality of the soil which the roots have come to in their downward growth. If the number of concentric rings in a transverse section has shown the age of a tree, and its girth has been ascertained by measurement, an approximation to the age of any other tree of the same kind still growing, under similar circumstances, may be determined by comparison. In this way the age of many remarkable trees has been ascertained. The yew attains a greater age than any other tree in Europe. According to M. De Candolle this tree increases in girth

the twelfth part of an inch in a year during the first 150 years, and rather less in the next hundred, the increase probably decreasing progressively. By that estimate a yew at Fountaine Abbey was reckoned by Pennant to be 1214 years old; one at Crowhurst, in Surrey, was 1400 years old when measured by Evelyn; it has been shown by the same method that a yew at Fotherngill, in Scotland, was between 2500 and 2600 years old; and one at Braburn, in Kent, must have been 3000 years old: these are the veterans of European vegetation.

The cypress rivals the yew in longevity, and may perhaps surpass it. There is a cypress in the palace garden at Grenada which had been celebrated in the time of the Moors, and was still known in the year 1776, as Cipres della Regina Sultana, because a sultana met with Abencerrages under its shade. Oaks come next in order: they are supposed to live 1500 or 1600 years. One in Welbec Lane mentioned by Evelyn was computed to be 1400 years old. Chesnut-trees are known to live 900 years; lime-trees have attained 500 or 600 years in France; and birches are supposed to be equally durable. Some of the smaller and less conspicuous European plants perhaps rival these giants of the forest in age: heaths, and the alpine willow, which covers the ground with its leaves, although it is really a subterranean tree spreading to a vast distance, are long lived. Ivy is another example of this: there is one near Montpellier, six feet in girth, which must be 485 years old. A lichen was

watched for forty years without the appearance of change.

The antiquity of these European vegetables sinks into insignificance when compared with the celebrated baobab, or Adansonia digitata, in Senegal: taking as a measure the number of concentric rings counted on a transverse incision made for the purpose in the trunk of that enormous tree, it was proved to be 5150 years old; yet Baron Humboldt considers a cypress in the garden of Chapullepec to be still older; it had already reached a great age when Montezuma was on the throne of Mexico, in 1520. These two trees are probably the most aged organized beings on the face of the earth. Eight olive-trees on the Mount of Olives are supposed to be 800 years old; it is at least certain that they existed prior to the taking of Jerusalem by the Turks. There is some doubt as to the age of the largest cedar on Lebanon; it is nine feet in diameter, and has probably existed 800 or 900 years. There are two cedar-trees in the Botanic Garden at Chelsea which were mentioned 600 years ago.

The age of palms and other monocotyledonous plants is ascertained by a comparison of their height with the time which each kind takes to grow. M. De Candolle thus estimates that the Cocos oleracea, or cabbage-palms, may live 600 or 700 years, while the cocoa-nut palm lives from 80 to 330 years.

Mr. Babbage has made an approximation to the age of peat-mosses from the concentric rings of the trees found in them.

MARINE VEGETATION.

A vegetable world lies hid beneath the surface of the ocean, altogether unlike that on land, and existing under circumstances totally different with regard to light, heat, and pressure, yet sustained by the same means. Carbonic acid and ammonia are as essential, and metallic oxides are as indispensable, to marine vegetation as they are to land-plants. Sea-water contains ammonia, and something more than a twelve-thousandth part of its weight of carbonate of lime, yet that minute portion is sufficient to supply all the shell-fish and coral-insects in the sea with materials for their habitations, as well as food for vegetation. Marine plants are more expert chemists than we are, for the water of the ocean contains rather less than a millionth part of its weight of iodine, which they collect in quantities impossible for us to obtain otherwise than from their ashes.

Sea-weeds fix their roots to anything—to stone, wood, and to other sea-weeds: they must therefore derive all their nourishment from the water, and the air it contains; and the vital force or chemical energy by which they decompose and assimilate the substances fit for their maintenance is the sun's light.

Marine plants, which are very numerous, consist of two groups—a jointed kind, which include the Confervæ, or plants having a thread-like form; and a jointless kind, to which belong dulse, laver, the kinds used for making kelp, vegetable glue, iodine, that in the Indian Archipelago, of which the sea-swallows

make their edible nests, and all the gigantic species which grow in submarine forests, or float like green meadows in the open sea. Flower-bearing sea-weeds are very limited in their range, which depends upon the depth of water and the nature of the coasts; but the cryptogamic kinds are widely dispersed, some species are even found in every climate from pole to pole. No doubt the polar currents at the surface, and the stratum of uniform temperature lower down, are the highways by which these cosmopolites travel.[1]

There are fewer vegetable provinces in the seas than on land, because the temperature is more uniform, and the dispersion of the plants is not so much interfered with by the various causes which disturb it on land.[2]

Marine vegetation varies both horizontally and

[1] The cosmopolite ulvæ are the Enteromorpha, Codium, &c.

[2] Dr. J. D. Hooker has divided the marine vegetation into ten provinces:—the Northern Ocean, from the pole to the 60th parallel of north latitude;—the North Atlantic, between the 60th and 40th parallels, which is the province of the delessariæ and fucus proper;—the Mediterranean, which is a sub-region of the warmer temperate zone of the Atlantic, lying between the 40th and 23rd northern parallels;—the tropical Atlantic, in which sargassum, rhodomelia, corallinia, and siphinea abound;—the antarctic American region, from Chile to Cape Horn, the Falkland Islands, and the whole circumpolar ocean south of the 50th southern parallel;—the Australian and New Zealand province, which is very peculiar, being characterized, among other generic forms, by cystoseiriæ and fuceæ;—the Indian Ocean and the Red Sea;—and the last, which comprises the Japan and China Seas. There are several undetermined botanical marine provinces in the Pacific and elsewhere.

vertically with the depth, and it seems to be a general law throughout the ocean that the light of the sun and vegetation end together; it consequently depends on the power of the sun and the transparency of the water; so different kinds of sea-weeds affect different depths, where the weight of the water, the quantity of light and heat, suit them best. One great marine zone lies between the high and low water marks, and varies in species with the nature of the coasts, but exhibits similar phenomena throughout the northern hemisphere. In the British seas, where, with two exceptions, the whole flora is cryptogamic,[1] this zone does not extend deeper than 30 fathoms, but is divided into two distinct provinces, one to the south and another to the north. The former includes the southern and eastern coasts of England, the southern and western coasts of Ireland, and both the channels; while the northern flora is confined to the Scottish seas and the adjacent coasts of England and Ireland. The second British zone begins at low-water mark, and extends below it to a depth from 7 to 15 fathoms. It contains the great tangle sea-weeds, growing in miniature forests, mixed with fuci, and is the abode of a host of animals. A coral-like sea-weed is the last plant of this zone, and the lowest in these seas, where it does not extend below the depth of 60 fathoms, but in the Mediterranean it is found at 70 or 80 fathoms, and is the lowest plant in that sea. The same law prevails in

[1] The British flowering sea-weeds are the Zostera and Zanichellia.

the Bay of Biscay, where one set of sea-weeds is never found lower than 20 feet below the surface; another only in the zone between the depths of 5 and 30 feet; and another between 15 and 35 feet. In these two last zones they are most numerous; at a greater depth the kinds continue to vary, but their numbers decrease. The seeds of each kind float at the depth most genial to the future plant; they must therefore be of different weights. The distribution in the Egean Sea was found by Professor E. Forbes to be perfectly similar, only that the vegetation is different, and extends to a greater depth in the Mediterranean than in more northern seas.[1] He also observed that sea-weeds growing near the surface are more limited in their distribution than those that grow lower down, and that with regard to vegetation depth corresponds with latitude, as height does on land.

[1] The vegetation at different depths in the Egean Sea is as distinctly marked as that at different heights on the declivity of a mountain. The coast plants are the Padina pavonia and Dictyota dichotoma. A greater depth is characterized by the vividly green and elegant fronds of the Caulerpa prolifera, probably the prasium of the ancients; associated with it are the curious sponge-like Codium Bursa, and four or five others. The Codium flabelliforme, and the rare and curious vegetable net called Microdictyon umbilicatum, characterize depths of 30 fathoms. The Dictyomenia, with stiff purple corkscrew-like fronds, and some others, go as low as 50 fathoms, beyond which no flexible sea-weeds have been found. The coral-like Millepora polymorpha take their place, and range to the depth of 100 fathoms, beyond which there is no trace of vegetable life, unless some of the minute and microscopic infusorial bodies living there be regarded as plants.—'Travels in Lycia,' by Lieutenant Spratt, R.N., and Professor E. Forbes.

Thus the flora at great depths, in warm seas, is represented by kindred forms in higher latitudes. There is every reason to believe that the same laws of distribution prevail throughout the ocean and every sea.

Sea-weeds adhere firmly to the rocks before their fructification, but they are easily detached afterwards, which accounts for some of the vast fields of floating weeds; but others, of gigantic size and wide distribution, are supposed to grow unattached in the water itself. There are permanent bands of sea-weed in our British Channel and in the North Sea, of the kind called Fucus Filum, which grow abundantly on the western coasts of the Channel, and they lie in the direction of the currents, in beds 15 or 20 miles long, and not more than 600 feet wide. These bands must oscillate with the tides between two corresponding zones of rest, one at the turn of the flood, and the other at the turn of the ebb. It is doubtful whether the Fucus natans or Sargassum bacciferum grows on rocks at the bottom of the Atlantic, between the parallels of 40° north and south of the equator, and, when detached, is drifted uniformly to particular spots which never vary, or whether it is propagated and grows in the water; but the mass of that plant, west of the Azores, occupies an area equal to that of France, and has not changed its place since the time of Columbus. Fields of the same kind cover the sea at the Bahama Islands and other places, and two new species of it were discovered in the Antarctic seas.

The Macrocystis pyrifera and the Laminaria

radiata are the most remarkable of marine plants for their gigantic size and the extent of their range. They were met with on the Antarctic coasts two degrees nearer the south pole than any other vegetable production, forming, with one remarkable exception, the utmost limit of vegetable life in the south polar seas. The Macrocystis pyrifera exists in vast detached masses, like green meadows, in every latitude from the south polar ocean to the 45th degree N. lat. in the Atlantic, and to the shores of California in the Pacific, where there are fields of it so impenetrable, that it has saved vessels driven by the heavy swell towards that shore from shipwreck. It is never seen where the temperature of the water is at the freezing-point, and is the largest of the vegetable tribe, being occasionally 300 or 400 feet long. The Laminaria abounds off the Cape of Good Hope and in the Antarctic Ocean. These two species form great part of a band of sea-weed that girds Kerguelen Islands so densely, that a boat can scarcely be pulled through it; and they are found in great abundance on the coasts of the Falkland group, and also in vast fields in the open sea, hundreds of miles from any land: had it ever grown on the distant shores, it must have taken ages to travel so far, drifted by the wind, currents, and the sand of the seas. The red, green, and purple lavers of Great Britain are found on the coasts of the Falkland Islands; and, though some of the northern weeds are not found in the intervening warm seas, they reappear here. The Lessonia is the most remarkable

marine plant in this group of islands. Its stems, much thicker than a man's leg, and from 8 to 10 feet long, fix themselves by clasping fibres to the rocks beyond the high-water mark. Many branches shoot upwards from these stems, from which long leaves droop into the water like willows. There are immense submarine forests off Patagonia and Tierra del Fuego, attached to the rocks at the bottom. These plants are so strong and buoyant, that they bring up large masses of stone; and, as they grow slanting, and stretch along the surface of the sea, they are sometimes 300 feet long. The quantity of living creatures which inhabit these marine forests and the parasitical weeds attached to them is inconceivable, they absolutely teem with life. Of the species of marine plants which are strictly antarctic, including those in the seas of Van Diemen's Land and New Zealand, Dr. Hooker has identified one-fifth with the British Algæ.

The high latitudes of the Antarctic Ocean are not so destitute of vegetation as was at first believed. Most minute objects, altogether invisible to the naked eye, except in mass, and which were taken for siliceous shelled animalcules of the infusoria kind, prove to be vegetable. They are a species of the Diatomaceæ, which, from their multitudes, give the sea a pale ochreous brown colour. They increase in numbers with the latitude, up to the highest point yet attained by man, and no doubt afford the supply of food to many of the minute animals in the antarctic seas. Genera and species of this plant exist in every

sea from Victoria Land to Spitzbergen. It is one of the remarkable instances of a great end being effected by small means; for the death of this antarctic vegetation is forming a submarine bank between the 76th and 78th parallels of south latitude, and from the 165th to the 160th western meridian.

Great patches of Confervæ are occasionally met with in the high seas. Bands several miles long, of a reddish-brown species, like chopped hay, occur off Bahia, on the coast of Brazil; the same plant is said to have given the name to the Red Sea; and different species are common in the Australian seas.

CHAPTER XXVIII.

Distribution of Insects.

EE hundred thousand insects are known: some wings, others without; some are aquatic, others ıquatic only in the first stage of their existence, many are parasitical. Some land insects are ivorous, others feed on vegetables; some of the ivorous tribe live on dead, others on living ıals, but they are not half so numerous as those live on vegetables. Some change as they are :loped; in their first stage they eat animal food, vegetables when they come to maturity.

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CHAPTER XXVIII.

Distribution of Insects.

THREE hundred thousand insects are known: some with wings, others without; some are aquatic, others are aquatic only in the first stage of their existence, and many are parasitical. Some land insects are carnivorous, others feed on vegetables; some of the carnivorous tribe live on dead, others on living animals, but they are not half so numerous as those that live on vegetables. Some change as they are developed; in their first stage they eat animal food, and vegetables when they come to maturity.

Insects maintain the balance among the species of the vegetable creation by preventing the tendency that plants have to encroach on one another. The stronger would extirpate the weaker, and the larger would destroy the smaller, were it not checked by insects which live on vegetables. On the other hand, many plants would be extirpated by insects were these not devoured by other insects and spiders.

Of the 8000 or 9000 British insects the greatest part are carnivorous, and therefore keep the others within due bounds.

Insects increase in kinds and in numbers from the poles to the equator: in a residence of 11 months in Melville Island, Sir Edward Parry found only 6 species, because lichens and mosses do not afford nou-

rishment for the insect tribes, though it is probable that every other kind of plant gives food and shelter to more than one species; it is even said that 40 different insects are quartered upon the common nettle.

The increase of insects from the poles to the equator does not take place at the same time everywhere. The polar regions and New Holland have very few specifically and individually; they are more abundant in Northern Africa, Chile, and in the plains west of the Brazils; North America has fewer species than Europe in the same latitude, and Asia has few varieties of species in proportion to its size; Caffraria, the African and Indian islands, possess nearly the same number of species; but by far the richest of all, both in species and numbers, are central and intertropical America. Beetles are an exception to the law of increase towards the equator, as they are infinitely more numerous in species in the temperate regions of the northern hemisphere than in equatorial countries. The location of insects depends upon that of the plants which yield their food; and, as almost each plant is peopled with inhabitants peculiar to itself, insects are distributed over the earth in the same manner as vegetables; the groups, consequently, are often confined within narrow limits, and it is extraordinary that, notwithstanding their powers of locomotion, they often remain within a particular compass, though the plants, and all other circumstances in their immediate vicinity, appear equally favourable for their habitation.

The insects of eastern Asia and China are different from those in Europe and Africa; those in the United States differ specifically from the British, though they often approach very near; and in South America the equinoctial districts of New Grenada and Peru have distinct groups from those in Guiana.

Though insects are distributed in certain limited groups, yet most of the families have representatives in all the great regions of the globe, and some identical species are inhabitants of countries far from one another. The Vanessa Cardui, or "Painted Lady Butterfly," is found in all the four quarters of the globe and in Australia; and one, which never could have been conveyed by man, is native in southern Europe, the coast of Barbary, and Chile. It is evident from these circumstances that not only each group, but also each particular species, must have been originally created in the places they now inhabit.

Mountain-chains are a complete barrier to insects, even more so than rivers: not only lofty mountains like the Andes divide the kinds, but they are even different on the two sides of the Col de Tende in the Alps. Each soil has kinds peculiar to itself, whether dry or moist, cultivated or wild, meadow or forest. Stagnant water and marshes are generally full of them; some live in water, some run on its surface, and every water-plant affords food and shelter to many different kinds. The east wind seems to have considerable effect in bringing the insect or in developing the eggs of certain species; for example, the aphis, known as the blight in or

country, lodges in myriads on plants, and shrivels up their leaves after a continued east wind. They are almost as destructive as the locust, and sometimes darken the air by their numbers. Caterpillars are also very destructive; the caterpillar of the Y moth would soon ruin the vegetation of a country were it not a prey to some other. Insects sometimes multiply suddenly to an enormous extent, and decrease as rapidly and as unaccountably.

Temperature, by its influence on vegetation, has an indirect effect on the insects that are to feed upon plants, and extremes of heat and cold have more influence on their locality than the mean annual temperature. Thus in the polar regions the mosquito tribes are more numerous and more annoying than in temperate countries, because they pass their early stages of existence in water, which shelters them, and the short but hot summer is genial to their brief span of life.

In some instances height corresponds with latitude. The Parnassius Apollo, a butterfly native in the plains of Sweden, is also found in the Alps, the Pyrenees, and a closely allied species in the Himalaya. The Parnassius Smyntheus, true to the habitat of the genus, has recently been found on the Rocky Mountains of North America. Some insects require several years to arrive at their perfect state; they lie buried in the ground in the form of grubs: the cockchafer comes to maturity in 3 years, and some American species require a much longer time.

Insects do not attain their perfect state till the

plants they are to feed upon are ready for them. Hence in cold and temperate climates their appearance is simultaneous with vegetation; and as the rainy and dry seasons within the tropics correspond to our winter and summer, insects appear there after the rains and vanish in the heat: the rains, if too violent, destroy them; and in countries where that occurs there are two periods in the year in which they are most abundant—one before and one after the rains. It is also observed in Europe that insects decrease in the heat of summer and become more numerous in autumn: the heat is thought to throw some into a state of torpor, but the greater number perish.

It is not known that any insect depends entirely upon only one species of plant for its existence, or whether it may not have recourse to congeners should its habitual plant perish. When particular species of plants of the same family occur in places widely apart, insects of the same genus will be found on them, so that the existence of the plant may often be inferred from that of the insect, and in several instances the converse.

When a plant is taken from one country to another in which it has no congeners, it is not attacked by the insects of the country: thus our cabbages and carrots in Cayenne are not injured by the insects of that country, and the tulip-tree and other magnolias are not molested by our insects; but if a plant has congeners in its new country, the inhabitants will soon find their way to the stranger.

The common fly is one of the most universal of insects, yet it was unknown in some of the South Sea islands till it was carried there by ships from Europe, and it has now become a plague.

The mosquito and culex are spread over the world more generally than any other tribe: they are the torment of men and animals from the poles to the equator by night and by day: the species are numerous and their location partial. In the Arctic regions the Culex Pipiens, which passes two-thirds of its existence in water, swarms in summer in myriads: the lake Myvatr, in Iceland, has its name from the legions of these tormentors that cover its surface. They are less numerous in central Europe, though one species of mosquito, the Simulium columbaschense, which is very small, appears in such clouds in parts of Hungary, especially the Bannat of Temeswar, that it is not possible to breathe without swallowing many: even cattle and children have died from them. In Lapland there is a plague of the same kind. Of all places on earth the Orinoco and other great rivers of tropical America are the most obnoxious to this plague. The account given by Baron Humboldt is really fearful: at no season of the year, at no hour of the day or night, can rest be found; whole districts in the upper Orinoco are deserted on account of these insects. Different species follow one another with such precision, that the time of day or night may be known accurately from their humming noise, and from the different sensations of pain which the different poisons produce.

The only respite is the interval of a few minutes between the departure of one gang and the arrival of their successors, for the species do not mix. On some parts of the Orinoco the air is one dense cloud of poisonous insects to the height of 20 feet. It is singular that they do not infest rivers that have black water, and each white stream is peopled with its own kinds; though ravenous for blood, they can live without it, as they are found where no animals exist.

In Brazil the quantity of insects is so great in the woods, that their noise is heard in a ship at anchor some distance from the shore.

Various genera of butterflies and moths are very limited in their habitations, others are dispersed over the world, but the species are almost always different. Bees and wasps are equally universal, yet each country has its own. The common honey-bee is the only European insect directly useful to man; it was introduced into North America not many years ago, and is now spread over the continent: it is now naturalized in Van Diemen's Land and New Zealand. European bees, of which there are many species, generally have stings; the Australian bee, like a black fly, is without a sting; and in Brazil there are 30 species of stingless bees.

Fire-flies are mostly tropical, yet there are four species in Europe; in South America there are three species, and so brilliant that their pale green light is seen at the distance of 200 paces.

The silkworm comes from China, and the cochi-

neal insect is a native of tropical America: there are many species of it in other countries. The Coccus Lacca is Indian, the Coccus Ilicis lives in Italy, and there is one in Poland, but neither of these have been cultivated.

Scorpions under various forms are in all warm climates; 2 or 3 species are peculiar to Europe, but they are small in comparison with those in tropical countries: one in Brazil is six inches long. As in mosquitos, the poison of the same species is more active in some situations than in others. At Cumana the sting of the scorpion is little feared, while that of the same species in Carthagena causes loss of speech for many days.

Ants, Formicidæ (Hymenoptera), are universally distributed, but of different kinds. Near great rivers they build their nests above the line of the annual inundations. The insects called white ants, belonging to a different genus and family Termitidæ (Neuroptera), are so destructive in South America, that Baron Humboldt says there is not a manuscript in that country a hundred years old.

There are upwards of 1200 species of spiders and their allies known; each country has its own, varying in size, colour, and habits, from the huge bird-catching spider of South America, to the almost invisible European gossamer floating in the air on its silvery thread. Many of this ferocious family are aquatic; and spiders, with some other insects, are said to be the first inhabitants of new islands.

The migration of insects is one of the most curious circumstances relating to them: they sometimes appear in great flights in places where they never were seen before, and they continue their course with perseverance which nothing can check. This has been observed in the migration of crawling insects. caterpillars have attempted to cross a stream. Countries near deserts are most exposed to the invasion of locusts, which deposit their eggs in the sand, and, when the young are hatched by the sun's heat, they emerge from the ground without wings; but as soon as they attain maturity, they obey the impulse of the first wind, and fly, under the guidance of a leader, in a mass, whose front keeps a straight line, so dense that it forms a cloud in the air, and the sound of their wings is like the murmur of the distant sea. They take immense flights, crossing the Mozambique Channel from Africa to Madagascar, which is 120 miles broad: they come from Barbary to Italy, and a few have been seen in Scotland. Even the wandering tribes of locusts differ in species in different deserts, following the universal law of organized nature. Insects, not habitually migratory, sometimes migrate in great flocks. In 1847 lady-birds or coccinellæ and the bean aphis arrived in immense multitudes at Ramsgate and Margate from the continent, in fine calm weather, and a mass of the Vanessa cardui flew over a district in a column from 10 to 15 yards wide, for 2 hours successively. Why these butterflies should simultaneously take wing in a flock is unaccountable, for had it been for

want of food they would probably have separated in quest of it. In 1847 the cabbage butterfly came in a mass from the coast of France to England. Dragon-flies migrate in a similar manner. Professor Ehrenberg has discovered a new world of creatures in the Infusoria, so minute that they are invisible to the naked eye. He found them in fog, rain, and snow, in the ocean, in stagnant water, in animal and vegetable juices, in volcanic ashes and pumice, in opal, in the dusty air that sometimes falls on the ocean; and he detected 18 species 20 feet below the surface of the ground in peat-earth, which was full of microscopic live animals: they exist in ice, and are not killed by boiling water. This lowest order of animal life is much more abundant than any other, and new species are found every day. Magnified, some of them seem to consist of a transparent vesicle, and some have a tail: they move with great alacrity, and show intelligence by avoiding obstacles in their course: others have siliceous shells. Language, and even imagination, fails in the attempt to describe the inconceivable myriads of these invisible inhabitants of the ocean, the air, and the earth: they no doubt become the prey of larger creatures, and perhaps bloodsucking insects may have recourse to them when other prey is wanting.

CHAPTER XXIX.

Distribution of Marine Animals in general—Fishes—the Marine Mammalia—Phocæ, Dolphins, and Whales.

Before Sir James Ross's voyage to the Antarctic regions, the profound and dark abysses of the ocean were supposed to be entirely destitute of animal life; now it may be presumed that no part of it is uninhabited, since during that expedition live creatures were fished up from a depth of 6000 feet. But as most of the larger fish usually frequent shallow water near the coasts, deep seas must form barriers as impassable to the greater number of them as mountains do to land animals. The polar, the equatorial ocean, and the inland seas, have each their own particular inhabitants; almost all the species and some of the genera of the marine creation are different in the two hemispheres, and even in each particular sea; and under similar circumstances the species are for the most part representative, though not the same. Identity of species, however, does occur, even at the two extremities of the globe, for living animals were brought up from the profound depths of the Antarctic Ocean which Sir James Ross recognised to be the very same species which he had often met with in the Arctic seas. "The only way they could have got from the one pole to the other must have been through the tropics; but the temperature of the sea in these re-

gions is such that they could not exist in it unless at a depth of nearly 2000 fathoms. At that depth they might pass from the Arctic to the Antarctic Ocean without a variation of 5 degrees of temperature; whilst any land animal, at the most favourable season, must experience a difference of 50 degrees, and, if in winter, no less than 150 degrees of Fahrenheit's thermometer;"—a strong presumption that marine creatures can exist at the depth and under the enormous pressure of 12,000 feet of water. The stratum of constant temperature in the ocean may indeed afford the means of migration from pole to pole to those which live in shallower water, as they would only have to descend to a depth of 7200 feet at the equator. The great currents, no doubt, offer paths for fish without any sudden change of temperature: the inhabitants of the Antarctic Sea may come to the coasts of Chile and Peru by the cold stream that flows along them from the south polar ocean, and, on the contrary, tropical fish may travel by the Gulf-stream to the middle and high latitudes in the Atlantic, but few will leave either one or other to inhabit the adjacent seas, on account of the difference of heat. Nevertheless quantities of medusæ or sea-nettles are brought by the Gulf-stream to feed the whales at the Azores, though the whales themselves never enter the stream, on account of its warmth.

The form and nature of the coasts have great influence on the distribution of fishes; when they are uniformly of the same geological structure, so as to

afford the same food and shelter, the fish are similar. Their distribution is also determined by climate, the depth of the sea, the nature of the bottom, and the influx of fresh water.

The ocean, the most varied and most wonderful part of the creation, absolutely teems with life: "things innumerable, both great and small, are there." The forms are not to be numbered even of those within our reach; yet, numerous as they are, few have been found exempt from the laws of geographical distribution.

The discoloured portions of the ocean generally owe the tints they assume to myriads of insects. In the Arctic seas, where the water is pure transparent ultramarine colour, parts of 20 or 30 square miles, 1500 feet deep, are green and turbid from the quantity of minute animalcules. Captain Scoresby calculated that it would require 80,000 persons, working unceasingly from the creation of man to the present day, to count the number of insects contained in 2 miles of the green water. What, then, must be the amount of animal life in the polar regions, where one-fourth part of the Greenland Sea, for 10 degrees of latitude, consists of that water! These animalcules are of the medusa tribe, mixed with others that are moniliform. Some medusæ are very large, floating like jelly; and although apparently carried at random by the waves, each species has its definite location, and even organs of locomotion. One species comes in spring from the Greenland seas to the coast of Holland; and Baron

Humboldt met with an immense shoal of them in the Atlantic, migrating at a rapid rate.

Dr. Pœppig mentions a stratum of red water near Cape Pilares, 24 miles long and 7 broad, which seen from the mast-head appeared dark-red, but on proceeding it became a brilliant purple, and the wake of the vessel was rose-colour. The water was perfectly transparent, but small red dots could be discerned moving in spiral lines. The vermilion sea off California is no doubt owing to a similar cause, as Mr. Darwin found red and chocolate-coloured water on the coast of Chile over spaces of several square miles full of microscopic animalcules, darting about in every direction, and sometimes exploding. Infusoria are not confined to fresh water; the bottom of the sea swarms with them. Siliceous-coated infusoria are found in the mud of the coral islands under the equator; and 68 species were discovered in the mud in Erebus Bay, near the Antarctic pole. These minute forms of organised being, invisible to the naked eye, are intensely and extensively developed in both of the polar oceans, and serve for food to the higher orders of fish in latitudes beyond the limits of the larger vegetation, though they themselves probably live on the microscopic plant already mentioned, which abounds in all seas. Some are peculiar to each of the polar seas, some are common to both, and a few are distributed extensively throughout the ocean.

The enormous prodigality of animal life supplies the place of vegetation, so scanty in the ocean in

comparison with that which clothes the land, and which probably would be insufficient for the supply of the marine creation, were the deficiency not made up by the superabundant land vegetation and insects carried to the sea by rivers. The fish that live on sea-weed must bear a smaller proportion to those that are predacious than the herbivorous land animals do to the carnivorous. Fish certainly are most voracious; none are without their enemies; they prey and are preyed upon; and there are two which devour even the live coral, hard as its coating is; nor does the coat of mail of shell-fish protect them. Whatever the proportion may be which predatory fish bear to herbivorous, the quantity of both must be enormous, for, besides the infusoria, the great forests of fuci and sea-weed are everywhere a mass of infinitely varied forms of being, either parasitical, feeding on them, seeking shelter among them, or in pursuit of others.

The observations of Professor E. Forbes in the Egean Sea show that depth has great influence in the geographical distribution of marine animals. From the surface to the depth of 230 fathoms there are eight distinct regions in that sea, each of which has its own vegetation and inhabitants. The number of shell-fish and other marine animals is greater specifically and individually between the surface and the depth of 2 fathoms than in all the regions below taken together, and both decrease downwards to the depth of 105 fathoms; between which and the depth of 230 only eight shells were found; and animal

life ceases in that part of the Mediterranean at 300 fathoms. The changes in the different zones are not abrupt; some of the creatures of an under region always appear before those of the region above vanish; and although there are a few species the same in some of the eight zones, only two are common to all. Those near the surface have forms and colours belonging to the inhabitants of southern latitudes, while those lower down are analogous to the animals of northern seas; so that in the sea depth corresponds with latitude, as height does on land. Moreover, the extent of the geographical distribution of any species is proportional to the depth at which it lives; consequently, those living near the surface are less widely dispersed than those inhabiting deep water. Professor Forbes also discovered several shells living in the Mediterranean that have hitherto only been known as fossils of the tertiary strata; and also that the species least abundant as fossils are most numerous alive, and the converse; hence the former are near their maximum, while the latter are approaching to extinction. These very important experiments, it is true, were confined to the Mediterranean; but analogous results have been obtained in the Bay of Biscay and in the British seas. There are four zones of depth in our seas, each of which has its own inhabitants, consisting of shell-fish, crustaceæ, corallines, and other marine creatures. The first zone lies between high and low water marks, consequently it is shallow in some places and 30 feet deep in others. In all parts of the northern hemi-

sphere it presents the same phenomena; but the animals vary with the nature of the coast, according as it is of rock, gravel, sand, or mud. In the British seas the animals of this littoral or coast zone are distributed in three groups that differ decidedly from one another, though many are common to all. One occupies the seas on the southern shores of our islands and both channels; a middle group has its centre in the Irish seas; and the third is confined to the Scottish seas, and the adjacent coasts of England and Ireland. The second zone extends from the low-water mark to a depth below it of from 7 to 15 fathoms, and is crowded with animals living on and among the sea-weeds, as radiated animals, shell-fish, and many zoophites. In the third zone, which is below that of vegetable life, marine animals are more numerous and of greater variety than in any other. It is particularly distinguished by arborescent creatures, that seem to take the place of plants, carnivorous mollusca, together with large and peculiar radiata. It ranges from the depth of 15 to 50 fathoms. The last zone is the region of stronger corals, peculiar mollusca, and of others that only inhabit deep water. This zone extends to the depth of 100 fathoms or more.

Except in the Antarctic seas, the superior zone of shell-fish is the only one of which anything is known in the great oceans, which have numerous special provinces. Many, like the harp, are tropical; others, as the nautilus and the pearl-oyster, are nearly so; the latter abounds throughout the Persian Gulf and

on the coasts of Borneo and Ceylon, which are thought to produce the finest pearls. There are many also in the Caribbean Sea, and in the Pacific, and especially in the Bay of Panama, but whether the species are different is not known. Some shells are exceedingly limited in their distribution, as the Haliotis gigantea, which is peculiar to the sea of Van Diemen's Land.

According to Sir Charles Lyell, nearly all the species of molluscous animals in the seas of the two temperate zones are distinct, yet the whole species in one bears a strong analogy to that in the other; both differ widely from those in the tropical and arctic oceans; and, under the same latitude, species vary with the longitude. The east and west coasts of tropical America have only one shell-fish in common; and those of both differ from the shell-fish in the islands of the Pacific and the Galapagos Archipelago, which forms a distinct region. Notwithstanding the many definite marine provinces, the same species are occasionally found in regions widely separated. A few of the shell-fish of the Galapagos Archipelago are the same with those of the Philippine islands, though so far apart. The east coast of America, which is poor in shell-fish, has a considerable number in common with the coasts of Europe.

The Cypræa moneta lives in the Mediterranean, the seas of South Africa, the Mauritius, the East Indies, China, and the South Seas even to Otaheite; and the Ianthina frangilis, the animal of which is of a beautiful violet-colour, floats on the surface in every

tropical and temperate sea. Mollusca have a greater power of locomotion than is generally believed. Some migrate in their larva state, being furnished with lobes which enable them to swim freely. The larva of the scalop is capable of migrating to distant regions; the argonauta spreads its sail and swims along the surface.

The numerous species of Zoophytes which construct the extensive coral banks and atolls are chiefly confined to the tropical seas of Polynesia, the East and West Indies: the family is represented by a very few species in our seas, and in the Mediterranean they are smaller and different generally from those in the torrid zone.

The larger and more active inhabitants of the waters obey the same laws with the rest of the creation, though the provinces are in some instances very extensive. Dr. Richardson observes that there is one vast province in the Pacific, extending 42 degrees on each side of the equator, between the meridians including Australia, New Zealand, the Malay Archipelago, China, and Japan, in which the genera are the same; but at its extremities the Arctic and Antarctic genera are mingled with the tropical forms. Many species however which abound in the Indian Ocean range as far north as Japan, from which circumstance it is presumed that a current sets in that direction. The middle portion of this province is vastly extended in longitude, for very many species of the Red Sea, the eastern coast of Africa, and the Mauritius range to the Indian

and China Seas, to those of northern Australia and all Polynesia; so in this immense belt, which embraces three-fourths of the circumference of the globe and 60 degrees of latitude, the fish are very nearly alike, the continuous chains of islands in the Pacific being favourable to their dispersion. Few of the Pacific fish enter the Atlantic;[1] and from the depth and want of islands in it the great bulk of species is different on its two sides. North of the 44th parallel however the number common to both shores increases. The salmon of America is identical with that of the British isles, the coasts of Norway and Sweden; the cod-fish is the same, as well as several others of the cod family. The Cottus or bullhead tribe are also the same on both sides of the North Atlantic, and they increase in numbers and variety on approaching the Arctic seas. The same occurs in the northern Pacific, though the generic forms differ from those in the Atlantic. From the near approach of the American and Asiatic coasts at Behring's Straits, the fish on both sides are nearly alike, down to the Sea of Okhotsk on one side and to Admiralty Inlet on the

[1] The notocanthus and macrourus are the deep-water fish in the arctic regions; they also inhabit the seas of New Zealand. The Pacific fish that enter the Atlantic are some of the mackarel tribe, sharks, and lophobranches. The genera most prevalent in the southern hemisphere are the notothemia, borichthys, and harpagifer. The same species of these genera are found in the seas of the Falkland Islands, Cape Horn, the Auckland Islands, and Kerguelen's Land.—Dr. Richardson.

other. The Japan Sea and the neighbouring coasts of China are frequented by fish having northern forms, which are there mingled with many species common to the temperate and warm parts of the ocean. Species of the genus Gadus or Cod reappear in the southern seas very like those of the northern; and two very remarkable Greenland genera, which inhabit deeper water and are seldom taken except when thrown up by a storm, have been discovered on the coasts of New Zealand and South Australia, where the fish differ but little from those in the seas of Van Diemen's Land. Several genera are peculiar to the southern hemisphere, and range throughout the whole circle of the high latitudes. The sharks of the China seas are for the most part identical with those of Australia: the cartilaginous fish to which they belong have a much wider range than those which have been under consideration.

The British islands lie between two great provinces of fishes—one to the south, the other to the north—from each of which we have occasionally visitors. The centre of the first is on the coasts of the Spanish peninsula, extending into the Mediterranean; that on the north has its centre about the Shetland Islands; but the group peculiarly British, and found nowhere else, has its focus in the Irish Sea. It is, however, mixed with fish from the seas bounding the western shores of central Europe, which form a distinct group.

The Prince of Canino has shown that there are 853 species of European fish, of which 210 live in fresh water, 643 are marine, and 60 of these go up

rivers to spawn. 444 of the marine fish inhabit the Mediterranean, 216 are British, and 171 are peculiar to the Scandinavian seas; so that the Mediterranean is richest in variety of species. In it there are peculiar sharks, sword-fish, dolphins, anchovies, and six species of scomber or tunny, one of the largest of edible fish, for which fisheries are established on the southern coasts of France, in Sardinia, Elba, the Straits of Messina, and the Adriatic. Four of the species are found nowhere else but in the Mediterranean. Rays of numerous species are particularly characteristic of the Mediterranean, especially the two torpedos, which have the power of giving an electric shock, and even the electric spark. The Mediterranean has two or three American species, 41 fish in common with Madeira, one in common with the Red Sea, and a very few seem to be Indian. Some of these fish must have entered the Mediterranean before it was separated from the Red Sea by the Isthmus of Suez; but geological changes have had very great influence on the distribution of fishes everywhere. Taking salt and fresh water fish together, there are 100 species common to Italy and Britain; and although the communication with the Black Sea is so direct, there are only 27 fish common to it and the Mediterranean; but the Black Sea forms a district by itself, having its own peculiar fish; and those in the Caspian Sea differ entirely from those in every other part of the globe. The island of Madeira, solitary amid a great expanse of ocean, has many species. They amount in number

to half of those in Britain; and nearly as many are common to Britain and Madeira as to that island and the Mediterranean; so that many of our fish have a wide range in the Atlantic. The Mediterranean certainly surpasses the British and Scandinavian seas in variety, though it is far inferior to either in the quantity or quality of useful fish. Cod, turbot, haddock, tusk, ling, herring, and many more, are better in northern seas than elsewhere, and several exist there only.

The greater number of fish used by man as food frequent shoal water. The coast of Holland, our own shores, and other parts of the North Sea where the water is shallow, teem with a never-ending supply of excellent fish of many kinds.

Vast numbers are gregarious and migratory. Cod arrive in the shallow parts of the coast of Norway in February, in shoals many yards deep, and so closely crowded together that the sounding-lead can hardly pass between them: 16,000,000 have been caught in one place in a few weeks. In April they return to the ocean. Herrings come in astonishing quantities in winter.

The principal cod fisheries are on the banks of Newfoundland and the Dogger-bank. They, like all animals, frequent the places to which they have been accustomed. Herrings come to the same places for a series of years, and then desert them, perhaps from having exhausted the food. Pilchards, mackerel, and many others, may be mentioned among the gregarious and migratory fish.

Sharks like deep water. They are found of different species in all tropical and temperate seas; and, although always dangerous, they are more ferocious in some places than in others, even of the same species.

Most lakes have fish of peculiar species, as the lake Baikal. The fishes of the great interalpine Lake of Titicaca amount to 7 or 8 species, and belong to genera only found in the higher regions of the Andes. In the North American lakes there is a thick-scaled fish, analogous to those of the early geological eras; and the gillaroo trout, which is remarkable in having a gizzard, is found in Ireland only. Pike and salmon are the only species of freshwater fish common to Europe and North America; the pike is however unknown west of the Rocky Mountains. The common salmon does not exist beyond 45° of N. lat. on the eastern coast of America, and it is probably confined within similar limits on the eastern coast of Asia. It is said to be an inhabitant of all the northern parts of the old world from the entrance of the Bay of Biscay to North Cape, and along the arctic shores of Asia and Kamtchatka to the Sea of Okhotsk, including the Baltic, White Sea, Gulf of Kara, and other inlets. Other kinds of the Salmon tribe are plentiful in the estuaries of Kamtchatka and on the opposite coast of America down to Oregon, but apparently they do not extend to China. Salmon go up rivers to spawn, and make extraordinary leaps over impediments of rocks or walls, in order

to reach the suitable places for depositing their eggs. Forty-four fish inhabit the British lakes and rivers, and 50 those of Scandinavia, of the very best kinds. The fresh-water fish of northern climates are better than those of the southern.

Each tropical river has its own species of fish. The fresh-water fish of China agree with those of India in generic forms, but not in species;[1] and those of the Cape of Good Hope and South America differ from those in India and China. Sea-fish, in immense quantities, frequent the estuaries of rivers everywhere. The mouth of the Mississippi is full of fish; and the quantity at the mouth of the Don, in the Sea of Azof, is prodigious.

There are some singular analogies between the inhabitants of the sea and those of the land. Many of the medusæ, two corallines, the Physalia, or Portuguese man-of-war, of sailors, and some others, sting like a nettle when touched. A cuttle-fish, at the Cape de Verde islands, changes colour like the chameleon, assuming the tint of the ground under it. Herrings, pilchards, and many other fish, as well as sea insects, are luminous. The medusa tribe, the species of which are numerous, have the faculty of shedding light in the highest degree. In warm climates, especially, the sea seems to be on fire, and the wake of a ship is like a vivid flame. Probably fish that go below the depths to which the light of the sun

[1] The Chinese fresh-water fish are cyprinidæ, ophicephali, and siluridæ—genera which agree closely with those in India, though the species are different.

penetrates are endowed with this faculty; and shoals of luminous insects have been seen at a considerable depth below the surface of the water. The glow-worm, some beetles, and fire-flies, shine with the same pale-green light. But among the terrestrial inhabitants there is nothing analogous to the property of the Gymnotus electricus of South America, the trembler, or Silurus electricus, of the African rivers, and the different species of the torpedo of the Mediterranean, which possess the faculty of giving the electric shock.

The marine mammalia, which, as their name indicates, suckle their young, form two distinct families—the Phocæ or seals, and the Cetacea or whales and porpoises: whilst fish breathe by means of gills, which separate the air dissolved in the water, the marine mammalia possess lungs and breathe as the terrestrial quadrupeds; they are obliged to come to the surface from time to time, consequently, to inhale the air.

The first family consists of the seal tribe, and is most abundant in the polar regions; they live exclusively on fish, are carnivorous, and are seldom found at a great distance from the land or ice islands. To this division belong the common seal and the walrus in our northern hemisphere; whilst the genus Otaria or sea-lion, with different forms and characters, and which attains in general a greater size, is only found in high southern latitudes.

The family of Cetacea consists of three great genera: the manati and dugong, which live in or

near the estuaries of tropical rivers, are herbivorous; the dolphins or porpoises, which are carnivorous, provided with long jaws and numerous teeth, and are found in almost every latitude and in every sea; and the whales, which, unprovided with cutting teeth, are furnished with whalebone inserted in the upper jaw, the extreme filaments of which are destined as a kind of net to catch the minute marine animals which form their food. The marine Cetacea breathe by an opening in the centre of the head, called, in whales, the blower, corresponding to the nose of terrestrial quadrupeds, and which also serves to expel the water taken into the mouth with the food, in the form of jets, which in the whale tribe varies in height and form according to the species.

The favourite haunts of the seal tribe are the polar oceans and desert islands in high latitudes, where they bask in hundreds on the sunny shores during the brief summer of these inhospitable regions, and become an easy prey to man, who has nearly extirpated the race in many places. A million are annually killed in the South Atlantic alone. Seven species are natives of the Arctic, Atlantic, and Polar Oceans; the Greenland seal, the bearded or great seal, and the Phoca leporina are found also in the high latitudes of the Northern Pacific. The Phoca oceanica is only in the White Sea and the sea at Nova Zembla, and the Phoca sagura on the coast of Newfoundland. The sea-lion is to be found on all the coasts of the South Pacific, but their principal gathering is on the island of St. George, one of the Prui-

biloff group, in lat. 56° N. The common seal is 6 or 7 feet long, with a face like that of a dog, and a large intelligent eye. It is easily tamed, and in the Orkney islands it is so much domesticated that it follows its master, and helps him to catch fish. This seal migrates in herds from Greenland twice in the year, and returns again to its former haunts; they probably come to the coasts of Europe and the British islands at the time of their migrations, but the Phoca vitulina is a constant inhabitant of our shores. Some of the seal tribe have a very wide range, as the fur species, Arctocephalus ursinus, of the Falkland islands, which at one time frequented the southern coasts of New Holland in multitudes, but they and three other species have now become scarce from the indiscriminate slaughter of old and young. Sir James Ross found some of the islands in the Antarctic seas overrun with the sea-elephant, Phoca elephantina, and they captured a new species of seal without external ears. The Walrus, a grim-looking creature, with tusks 2 feet long, bent downwards, and its nose covered with transparent bristles, has a body like that of a seal, 20 feet long, with a coat of short grey or yellow hair. It sleeps on the floating ice, feeds on sea-weed and marine animals, and never leaves the Arctic seas.

The manati and dugong form the first group of the family of the Cetacea; they are exclusively herbivorous, and inhabit near the mouths of the great tropical rivers. The lamantin or manatus of two species is found in the Amazon and Orinoco, and in

some rivers of Western Africa. In the former, where it is known as the sea-cow, its body is round like a wine-bag, and sometimes attains a length of 12 or 15 feet; it browses in herds on the herbage at the bottom of streams; and when attacked, the mother defends her young at the sacrifice of her own life. The dugong is an inhabitant of the eastern archipelago, and of the shallow parts of the Indian Ocean, where it also feeds on sea-weed; it is more a marine animal than the lamantin, as it is scarcely ever seen in fresh water. The dugong is so harmless and tame as to allow itself to be handled. When it suckles its young it sits upright, which has given rise to the fable of the Mermaid. This animal, like the lamantin, will sacrifice its life for its young, and is hence, among the Malays, held as the type of maternal affection. The animal called the Manatus septentrionalis, which frequents the Arctic seas, is very little known, and probably not one of the herbivorous Cetacea.

The second group or genus of the Cetacea consists of those of predatory habits; they live on fish, and consequently have sharp and numerous teeth, such as porpoises, dolphins, and spermaceti whales or Cachalots; they have, like all the animals of this family, spouting nostrils in the upper part of the head.[1] The common porpoise is seen spouting and tumbling on the surface of all the seas of Europe;

[1] The carnivorous Cetacea, with two remarkable exceptions, inhabit the ocean—the Delphinus Inca, of the Amazons and its affluents; and the D. Gangeticus, of the Ganges.

shoals of them go in pursuit of herrings and mackerel, and even swim up the rivers in chase of salmon. They have more the form of fish than the seal tribe, and have a dorsal fin. The several species of Dolphins, so remarkable for their voracity and for the swiftness of their motions, owing to the symmetry of their form and the width of their horizontally-placed tail, are seen in almost every latitude. The white dolphin, eaten by the Icelanders, is 18 feet long, and migrates from the Atlantic to Greenland in the end of November. The Grampus, Delphinus Orca, nearly allied to the killer of the South Sea whalers, is fierce and voracious, often 20 feet long, roams in numerous shoals, preying upon the larger fish, and even attacking the whale. The Grind or black dolphin has been known to run ashore in hundreds in the bays of Feroe, Orkney, and Shetland. This seems to be the same or nearly allied to the black fish which was met with in vast numbers by Sir James Ross in the Antarctic seas: they had so little fear, that they darted below the ship on one side and came up at the other. The white porpoise, Delphinus peronii, of the southern whalers, is a rare and elegant species of dolphin which chiefly inhabits the high southern latitudes, but has been seen at the equator in the Pacific. They are about six feet long, the hinder part of the head, the back, and the flukes of their tail are black, and all the rest of the purest white. The Narwhal or sea-unicorn (Monodon monoceros) has no teeth, but a tusk of fine ivory wreathed with a spiral groove extending 8 or

10 feet straight from the head; in general there is only one tusk, but there are always the rudiments of another, and occasionally both grow to an equal length. The old narwhals are white with blackish spots, the young are dark-coloured. This singular creature, which is about 16 feet long without the tusks, swims with great swiftness. Mr. Scoresby has seen 15 or 20 at a time playing round his ship in the Arctic seas, and crossing their long tusks in all directions as if they were fencing; they are found in all parts of the Northern Ocean.

The spermaceti whale, the Cachalot or Physeter Macrocephalus, belonging to the family of the predaceous spouters, is one of the most formidable inhabitants of the deep. Its average size is 60 feet long and 40 feet in circumference; its head, equal to a third of its length, is extremely thick and blunt in front, with a throat wide enough to swallow a man. The proportionally small swimming paws or pectoral fins are at a short distance behind the head, and the tail, which is a horizontal triangle 6 or 7 feet long, and 19 feet wide, with a notch between the flukes, is the chief organ of progressive motion and defence. It has a hump of fat on its back, is of a dark colour, but with a very smooth clean skin. These sperm whales have two nostrils on the top of their head, through which they throw at each expiration a succession of jets like smoke, at intervals of 15 or 20 minutes, after which they toss their tails high in the air and go head foremost to vast depths, where they remain for a considerable

time, and then return again to the surface to breathe. The jet or spout is from 6 to 8 feet high, and consists of water mixed with air, expired from the lungs. This whale has sperm-oil and spermaceti in every part of its body, but the latter is chiefly in a vast reservoir in its head, which makes it very buoyant, and ambergris is sometimes found in the inside of the body, supposed to be the produce of disease. These huge monsters, occasionally 75 feet long, go in great herds of 500 or 600, or schools, as the whalers call them. Females with their young, and two or three old males, generally form one company, and the young males another, while the old males feed and hunt singly. The sperm whales swim gracefully and equally, with their head above the water; but when a troop of them play on the surface of the water, some of these uncouth and gigantic creatures leap with the agility of a salmon several feet into the air, and fall down again heavily with a tremendous crash and noise like a cannon, driving the water up in lofty columns capped with foam. The fishery of the sperm whale is attended with great danger ; not only the wounded animal, but its companions who come to its aid, sometimes fight desperately, killing the whalers and tossing them into the air with a sweep of their tremendous tails, or biting a boat in two. In 1820 the American whaler Essex was wrecked in the Pacific by a sperm whale; it first gave the ship so severe a blow that it broke off part of the keel, then, retreating to a distance, it rushed furiously, and with its enormous head beat in a portion of the planks, and

the people had just time to save themselves in the boats when the vessel filled. They often lie and listen when suspicious of mischief. No part of the aqueous globe, except the Arctic seas, is free from their visits; they have been seen in the Mediterranean and the Adriatic, in the British Channel, and even in the estuary of the Thames, but their chief resort is the deepest parts of the warmer seas within or near the tropics, and in the Antarctic Ocean, where they feed on floating molluscæ, the sepia or cuttle-fish, &c.

The second and last genus of the Cetacea are whalebone whales, such as the Greenland whale and rorquals. Instead of teeth, the upper jaws of these animals are furnished with plates and filaments of whalebone, which are moveable, and are adapted to retain, as in a net, the medusæ and other small marine animals that are the food of these colossal inhabitants of the deep. The common Greenland species, Balæna Mysticetus, was formerly much more numerous, but it is now chiefly confined to the very high northern latitudes; however, should it be the same with the whale found in such multitudes in shallow water on the coasts of the Pacific and in the Antarctic Ocean by Sir James Ross, it must have a very wide range, but it is more probable that each pole has its own species. The Greenland whale is from 65 to 70 feet long, but they are so much persecuted that they probably never live long enough to come to their full size. The head is very large, but the opening of the throat is so narrow that it

can only swallow small animals. It has no dorsal fin: the swimming paws are about nine feet long, and the flat tail is half-moon shaped and notched in the middle. It has two spouts or nostrils, through which it throws jets like puffs of smoke some yards high. It only remains two or three minutes on the surface to breathe, and then goes under water for five or six. The back and tail are velvet-black, shaded in some places into grey, the rest is white: some are piebald. The capture of this whale is often attended with much cruelty, from their affection for their young; indeed the custom of killing the calf in order to capture the mother has ruined the fishery in several places, especially in New Zealand, where there were eight species of whales in vast abundance.

Rorquals are also whalebone whales, differing from the common whale in the more elongated form of the head. One species is from 80 to 100 feet long, the largest of marine animals. The bottle-nosed whale, a smaller species, was exceedingly numerous in the Arctic seas; in the year 1809, 1100 were stranded in Huelfiord in Iceland. This whale travels to lower latitudes in pursuit of herrings and other fish. It had been caught on the coast of Norway as early as the year 890, and probably long before. The first northern navigators were not attracted by the whale as an object of commerce, but stumbled upon it in their search for a north-west passage to the Pacific. The hump-backed whale, Balæna gibbosa, a rorqual 30 or 40 feet long, is met with in small herds in the intertropical and southern regions of the Pacific and

Atlantic; it is seldom molested by the whalers, and is very dangerous for boats, from the habit it has of leaping and rising suddenly to the surface. None of the senses of the whale tribe are very acute; the whalebone whales alone have the sense of smelling, and, although the sperm whale is immediately aware of a companion being harpooned at a very great distance, they do not hear well in air, and none have voice.[1]

The existence of creatures in the ocean resembling enormous serpents has been announced at different times for more than a century, but has never been authentically established. Accounts of such monsters having been seen in the northern seas, in the fiords of Norway and Sweden, had been given to the world by Egede and Pantoppidan: by the latter more on hearsay evidence than from his own observation. But as in every instance the pretended sea-serpent was represented to possess either the blow-holes of the Cetacea or the head and mane of a seal, it was evident the credulity of our Scandinavian neighbours had converted some well-known animals into the incomprehensible marine monsters of their imagination. The same may be said of the sea-serpent represented to have been stranded on one of the Orkney Islands in 1808, of which a part of the skeleton is preserved in the Museum of the College of Surgeons, and which, when examined by the naturalist, proved to belong to a large species of shark; and of that fallen in with off the coast of Halifax in 1833, by some British officers engaged on a fishing

[1] Captain Scoresby's 'Arctic Voyages.'

expedition. The existence of the sea-serpent was looked upon therefore as one of those creations of that imaginative credulity, so frequently entertained by ignorant seafaring persons, and had ceased to attract any attention except occasionally by an allusion to it in some Transatlantic newspaper; when it has been again revived by no less a person than the commander of one of her Majesty's ships, who has considered its discovery by him to be worthy of a report to the Lords of the Admiralty. The officer in question, Captain M'Quhae, of her Majesty's ship Dædalus, states that, on the 6th of August, 1848, being in lat. 24° 44′ S., long. 9° 22′ E., consequently not far from the south-western coast of Africa, he descried in broad daylight, and at a short distance, an animal with the head of a serpent and at least 60 feet long, passing his ship to the south-westward at the rate of 15 miles an hour. Professor Owen, after a careful and impartial consideration of all the details given of this strange apparition, has shown to the satisfaction of every unbiassed mind that the animal seen by the officers of the Dædalus was probably a large species of southern seal, and perhaps the Otaria Proboscidea. The genus Otaria is longer in proportion than our Arctic seals, and its fore flappers being situated farther back, the neck of the animal becomes longer, and is generally, in the act of swimming, raised out of the water, as seen and represented by Captain M'Quhae in his drawing. Professor Owen supposes that this seal had been carried from its usual haunts in or near the Antarctic circle on an

iceberg, which having melted away in these middle latitudes, the animal was obliged to find its way back by its own locomotive powers; an opinion rendered the more likely, when we consider that it was making for the nearest land, where such animals are known to live, Gough Island and Tristan d'Acunha, from which it was distant about 1500 miles, or 4 days' journey at the rate and in the direction it is represented by Captain M'Quhae to have been progressing when seen from his ship. This statement of the appearance therefore of the sea-serpent in 1848 adds nothing to our certainty as to the existence of such monsters; whilst it shows how easy it is, for even well-informed persons, to raise up imaginary beings out of animals well known to the naturalist. The general public, always fond of the marvellous and extraordinary, is too prone to credit such stories, and too ready to admit the existence of beings however opposed to all the known laws of organic co-existences. To persons ready to give credit to the assertions of those ignorant of the first principles of zoology, it would be a loss of time for the naturalist to endeavour to explain how impossible it is that the head and jaws of a serpent, with the skin and mane of a seal, and the blow-hole of a porpoise, could ever be found united in the same animal. As well might one try to reason with a believer in ghosts and fairies on the non-existence of those creations of a disordered imagination.

CHAPTER XXX.

Distribution of Reptiles — Frogs and Toads — Snakes, Saurians, and Tortoises.

Reptiles, more than any other class of animals, show the partial distribution of animated beings, because, being unable to travel to any great distance, they have remained in the places wherein they were originally stationed; and as they inhabit deserts, forests, and uncultivated ground, they have not been disturbed by man, who has only destroyed some individuals, but has not diminished the number of species, which is probably the same as ever it was. Few of the mammalia hybernate, or fall into a torpid state in winter, except the bear, marmot, bats, and some others. Their fat supplies the carbon consumed by the oxygen during their feeble and imperceptible respiration, and is wasted by the time the warm weather returns, which rouses them from their lethargy, thin and extenuated. But reptiles, being colder blooded, bury themselves in the ground, and hybernate during the winter in cold and temperate climates. In hot countries, they fall into a state of torpor during the dry season, so that they have no occasion to wander either on account of temperature or want of sustenance; and the few that do migrate in quest of food always return to their old haunts. As the blood of reptiles receives only a small part

of the oxygen they inhale, little heat and strength are generated; consequently they are cold-blooded, and for the most part sluggish in their motions, which, however, are more varied than in quadrupeds; but as some reptiles, such as tortoises and lizards, breathe more frequently than others, there are consequently great differences in their energy and sensibility.

The order of Reptiles is divided by naturalists into four classes, commencing in the ascending order:—1. Batracians or frogs, toads, and salamanders; 2. Ophidians or serpents; 3. Saurians, lizards, chameleons, crocodiles; and 4. Emydians or tortoises, and turtle. With very few exceptions they are oviparous; they partake of both terrestrial and aquatic forms, and many are amphibious: they all increase in numbers towards the equator, and few live in cold climates; but they can endure a cold winter better than a cool summer. Frogs and salamanders inhabit the banks of the M'Kenzie river in North America, where the mean temperature is between 7° and 8° of Fahrenheit; the thermometer in winter even sinks to 90° below the freezing point. The southern limit of reptiles, so far as it is known, is in 50° S. lat., where a frog was found on the banks of the river Santa Cruz.

The number of species of reptiles in the torrid zone is at least double that in the temperate; Australia has fewer than Europe, and of all places in the Old World, Java is richest in reptiles. America possesses more than half of all the species, the maximum being

in Brazil, but every one of them is peculiar to that continent alone.

The Batracians approach nearest to the nature of fishes, and form a link between land and water animals. As tadpoles they have tails and no feet, but when full-grown they generally acquire feet and lose their tails. Besides, in that early stage they are aquatic and breathe by gills, like fishes; but in a state of maturity they breathe by lungs like quadrupeds, though some of the genera always retain their gills and tails, and some never acquire feet. These animals have the power of retarding and accelerating their respiration without stopping the circulation of their blood, so that they can resist heat and cold to a certain degree—a power most remarkable in the salamander, which forms part of this class, so varied in appearance and nature. Some, as toads and frogs, imbibe a quantity of water, which is evaporated through their skin more or less quickly. This keeps them at the temperature of the medium they live in, and the air they inhale through the skin is as necessary to their existence as that which they breathe.

The group of toads and frogs consists of four families, which have four feet, but without tails; namely, frogs, hylas or rainettes, toads, and pipæ. Frogs, which are amphibious, have no nails on their toes, and their hind legs are longer than the fore, and webbed, consequently better fitted for swimming and jumping, which they do by leaps. There are 16 genera, and above 50 species, so that they are more

numerous and more varied than any other reptile. Of the hyla or tree-frog there are 60 species, all of the most vivid and brilliant tints, and several colours are frequently united on the same animal. They mostly live on high trees, and their webbed feet have little cushions at the points of their toes, forming a kind of sucker, by means of which they can squeeze out the air from under their feet, and, by the pressure of the atmosphere, they adhere firmly to the under side of the smoothest leaf, exactly on the same principle by which flies walk on the ceiling of a room. The bufo, or toad, is the ugliest of the race; many are hideous, with swollen bodies, wart-like excrescences, and obtuse toes. They seldom go into water, but frequent marshy, damp places, and only crawl, whereas the frog and hyla leap. They are much fewer than either of the other two families; only 30 species are known. The pipæ are also toads of a still more disgusting form, and are distinguished from their congeners by not having an extensile tongue. All these reptiles produce noises, which are exceedingly varied; they croak in concert, following a leader, and when he is tired another takes his place. One of the North American frogs croaks in bands; one band begins, another answers, and a third replies, till the noise is heard at a great distance; a pause then takes place, after which the croaking is renewed. Mr. Darwin mentions a little musical hyla at Rio de Janeiro, which croaks a kind of harmony in different notes.

Toads and frogs are found in almost all parts of

the earth, though very unequally and partially distributed. America has more than all the other countries taken together, and Europe the fewest. Six species of frogs, one rainette, and two toads, are European; and all, except four of the frogs, are also found in Asia and Africa. The Rana temporaria lives at the height of 7700 feet in the Pyrenees, and near the snow-line on the Alps.

The law of circumscribed distribution is strongly marked in Asia; for of ten species of frogs peculiar to that continent, three only are in the mainland, two are confined to Japan, and, of the five that are Javanese, one is also common to Amboina, and the other four to Bengal. The eight species of rainettes, or tree-frogs, are still more limited in their domicile; five of them are in Java only, and one in Japan; and the Hyla viridis is in Asia Minor. There are nine species of toad peculiar to Asia.

None of these reptiles exist in the Galapagos Archipelago, nor in any of the innumerable islands in Oceanica, and there are very few in Australia, but all peculiar. In Africa there are eight species of frogs, two or three of rainettes, and two of toads. One of the two species of pipa, more horrid in appearance than any toad, is very common at the Cape of Good Hope, and there only.

The great extent of marshes, rivers, and forests, together with the heat of the climate, make America the very home of reptiles of this kind, and there they grow to a greater size than anywhere else: 23 species of frog, 27 species of tree-frog or rai-

nette, and 21 of toads, are indigenous in that continent, not one of which is the same with any of those in the Old World; and most of those in South America are different from those in the northern part of the continent, though they are sometimes replaced by analogous kinds. All these reptiles have abodes, with fixed demarcations, often of small extent. The pipa, or toad of Surinam, is the most horrid of the tribe; the Bufo agua, of Brazil, 10 or 12 inches long, and the Rana pipiens, of Carolina, are the largest.

The second family of this class of reptiles have tails and feet, as the salamanders, which are very like lizards in their general form, having a long round or flattened tail and four feet. Some are terrestrial, and some are aquatic; the former are known as salamanders or newts, the latter as tritons. Both are met with in Europe, but the greater number are American. The amphibious genera of Amphiuma Menopoma and Syren, possessing both lungs and gills, are American; the latter are peculiar to the marshes and rice-grounds of Carolina, and the Axolotl is only found in the Lake of Mexico: they are very like eels with two feet. The Proteus anguinus, of a light flesh-colour, has four little feet and a flat tail, and has been found nowhere but in the dark subterraneous caverns in Carniola.

The third group of this order of Batracians are the Cæciliæ, of which there are only eight species, all inhabitants of the warm parts of Asia, Africa, and America. They have a cylindrical body, without feet or neck, and move exactly as the serpent, so they

seem to form the link between these reptiles and the class of frogs and toads.

There are serpents in all hot and temperate countries, but they abound most in intertropical regions. Java contains 56 species, which is a greater number comparatively than any other country, while in Borneo not one has been found. Those in Japan are peculiar. Wherever snakes exist, there also are some of the venomous kinds, but they are fewer specifically and individually than is generally supposed. Of 263 species, only 57 are venomous, or about one in five, although that proportion is not everywhere the same. In sterile, open countries, the proportion of venomous snakes is greater than in those that are covered with vegetation. Thus, in New Holland, seven out of ten species are poisonous; and in Africa, one of every two or three individuals is noxious. In general, however, the number of harmless individuals is 20 times as great as the number of the poisonous.

The three great families of venomous serpents are the colubriform or adder-shaped snakes, sea-serpents, and the triangular-headed snakes.

The adder-formed snakes are divided into three genera, the elaps, which are slender like a cord, with a small head and of brilliant colours. There are four species in South America, of which two are confined to Guiana, and one to Surinam, while the other is found everywhere from Brazil to Carolina. There is only one in Africa, three in Australia, and the rest are in limited districts in tropical Asia,

especially in Sumatra and Java; and an entire genus is found only in India, and the islands of Ceylon and Java. The hooded snakes (or Cobra Capello) are the best known of this family, especially the spectacled or dancing snake of the Indian jugglers, which is common everywhere from Malabar to Sumatra, and two other species are only found in Sumatra and Java. The three or four African species are chiefly at the Cape of Good Hope and on the Gold Coast; but the most celebrated is that generally known as the Egyptian asp, which has been tamed by magicians of ancient and modern times, and is frequently figured in Egyptian monuments; it derives some of its celebrity from Cleopatra's death. Two of the family inhabit New Holland, one of which is spectacled, like, but of a different species from, that in India.

All the seven species of sea-snakes are very venomous, and more ferocious than any other. They frequent the Indian Ocean in shoals from Malabar to the Philippine Islands and the Bay of Bengal; they never enter fresh water.

The third venomous family consists of the triangular-headed serpents, rattle-snakes, and vipers. The first are of a hideous aspect,—a large head, broad at the base like a heart, a wide mouth, with their hooked poisonous fangs strongly developed. They quietly watch their prey till it is within reach, then dart upon it, and inflict the deadly wound in a moment; the yellow viper of the French West India islands, the Trigonocephalus lanceolatus, being

amongst the most dangerous snakes in existence. One species in the Old World is to be met with everywhere from Ceylon to the Philippine Islands; one is a native in Sumatra, Timor, and Celebes; the rest are narrowly limited in their abode; two are confined to Java alone. Ceylon, Sumatra, Japan, and Tartary, have each a species of these serpents peculiar to itself.

The rattle-snakes are all American—two in the warm districts of North America, and two in the intertropical parts of South America. One of the latter, however, has a hard horn at the end of its tail, instead of a rattle, and sometimes grows to the length of 10 feet, being, with the Trigonocephalus, the longest of the venomous snakes.

Vipers come farther north than any other of the noxious tribe: two are Asiatic, though one is also common to Africa, which, however, has four peculiar to itself; and the only venomous serpents in Europe are three species of viper, one of which is also spread over the neighbouring parts of Asia and Africa. The common viper inhabits all central Europe and temperate Asia, even to Lake Baikal, in the Altaï Mountains: it is also found in England and Sweden, but it does not go farther west than the Seine, nor does it pass the Alps. One which frequents dry soils, in the south-east of Europe, is in Styria, Greece, Dalmatia, and Sicily; and the aspic viper, which lives on rocky ground, inhabits France between the Seine and the Pyrenees, Switzerland, Italy, and Sicily.

There are six families of innocuous serpents, consisting of numerous species. Four of the families are terrestrial; their species are very limited in their domicile, the greater number being confined to some of the islands of the Indian Archipelago, Ceylon, or to circumscribed districts in tropical Asia, Africa, and America. Nine or ten species are European, some of which are also found in Asia and Africa.

Tree-serpents of various genera and numerous species live only in the great tropical forests of Asia and America, especially in the latter. They are long and slender, the head for the most part ending in a sharp point, and generally green, though there are some of brighter colours; many of these serpents are fierce, though not venomous; some feed on birds, which they watch hanging by the tail from a bough.

In all temperate and warm countries abounding in lakes and rivers, fresh-water snakes are numerous; some live in the water, but they mostly inhabit the banks near it; they are excellent swimmers, and may be seen crossing lakes in shoals. America is particularly rich in them, there are several in Europe and Asia, but they are rare in Africa, and none have been yet discovered in Australia.

The genus Boa is peculiarly American, though some smaller in size and differing in species are found in Asia. The boa constrictor, generally from 9 to 15 feet long, lives in the great tropical forests of South America, where it often watches its prey hanging from the boughs of trees. Two of smaller size have

similar habits, and two are aquatic, one of which is sometimes 20 feet long, and another 6 feet; the latter inhabits banks of the rivers from the Amazons to Surinam; and a species is found at the foot of the Andes of Quito, as high as 3000 feet.

Pythons are the largest snakes of the eastern world, where they represent the boas of the western; one species, which sometimes attains the length of 20 feet, is spread from the western coast of Africa, throughout intertropical Asia, to Java and China. Another, only 14 feet long, is confined to Malacca and some of the Sunda Islands. Two others are found only in the islands of Timor and Saparua, and one in New Holland. There are only two species of Acrochordi, which, like boas and pythons, twist themselves round their victims and crush them to death: one aquatic, peculiar to Java; the other is a land snake, found everywhere through India to New Guinea.

The West Indian islands have the snakes of North and South America and some peculiar; the snakes of central America are little known.

Saurians have representatives in every warm and temperate climate. The crocodile, from its size and ferocity, claims the first place. There are three genera of this family, all amphibious, living in rivers, or in their estuaries: the Crocodile, properly speaking, common to the old and new continents;[1] the Alligator or Caiman, peculiar to America;

[1] One of the most celebrated species of this division is the crocodile of the Nile, which probably is to be met with in the

and the Gavial, which comes nearer to the form of certain fossil crocodiles than any other, is limited to the Ganges and other great rivers of India. The various species of crocodiles are confined to local habitations: three are Asiatic; two African, one of which is only in Sierra Leone; two are peculiar to Madagascar; and in America there are two species of crocodiles and five of alligators. The American crocodiles inhabit the estuaries of great rivers, a species is to be met with which ascends as high as 3000 feet at the base of the Andes of Quito.[1]

The alligators of the Mississippi, and of the rivers and marshes of Carolina, are more ferocious than those of South America, attacking men and animals; they only prey in the night; while in the water, like all their congeners, they cannot swallow their food, but they drown the animal they have caught, hide it under water till it is putrid, and then bring it to land to eat it. Locality has considerable influence on the nature and habits of these animals; in one spot they are very dangerous, while in another, at no great distance, they are cowardly. Alligators

western branch of that river, the Bahr-el-Abiad, as high as 4000 feet. Immense numbers of this species, of every size and age, are found embalmed in the catacombs of the ancient Egyptians, which are perfectly identical with the existing species, and offering another proof of the important fact first announced by Cuvier, from his examination of the mummies of the ibis, that no animal, in its wild state, had presented the least change, within the longest historical periods.

[1] Mr. Pentland informs me that crocodiles are found in some of the rivers of Bolivia at a much greater elevation.

are rarely more than 15 feet long, and are seen in large herds basking on the banks of rivers; their cry is like the roar of a bull; in a storm they bellow loudly, and are said to be much afraid of some of the whale family that ascend the great American rivers. The female watches her eggs and her young for months, never losing sight of them; but the male devours many of them when they go into the water. All animals of this class are covered with scales; those of the crocodile family are hard, horny, often osseous, and impenetrable.

Lizards are chiefly distinguished from crocodiles by having a long, thin, forked tongue like that of the viper; by their rapid motions, smaller size, and by some peculiarities of form.

The monitors, which are entirely confined to the old continent, have the tail compressed laterally, which enables them to swim rapidly: and they are furnished with strong sharp teeth. Many species inhabit Africa and India, especially the Indian Archipelago: the terrestrial crocodile of Herodotus is common on the deserts which surround Egypt; and an aquatic species in the Nile, which devours the crocodile's eggs, is often represented on the ancient Egyptian monuments.

Another group of the monitor family is peculiarly American; some of the species inhabiting the marshes in Guiana are 6 feet long.[1]

[1] Animals of a gigantic size, and allied to the lizard family, formerly inhabited the latitudes of Britain. A monster (the Mosasaurus) much surpassing the largest living crocodile is

Lizards are very common; more than 63 species are European, of which 17 inhabit Italy, and one lives on the Alps at an elevation of 4500 feet; the iguanians, which differ from them only in the form of the tongue, are so numerous in genera and species, that it would be in vain to attempt to follow all their ramifications, which are nevertheless distributed according to the same laws with other creatures: but the dragons, only found in India, are too singular to be passed over. The dragon is in fact a lizard with wings of skin, which are spread along its sides and attached to its fore and hind feet, like those of the bat, and, though they do not enable it to fly, they act like a parachute when the animal leaps from bough to bough in pursuit of insects. Nocturnal lizards of many species inhabit the hot countries of both continents; they are not unlike salamanders, but they have sharp claws, which they can draw in and conceal like those of a cat, and seize their prey. One of this species, the Gecko, climbs on walls in all the countries round the Mediterranean. Chameleons are frequent in northern Africa; and several species inhabit different districts and islands in Asia: the only European species is found in Spain; it is common to North Africa.

The anolis, which lives on trees, replaces the cha-

found in our Sussex chalk-beds; and an animal allied to the Iguana, the iguanodon of Mantell, is of frequent occurrence in the strata upon which the chalk reposes in the weald of Sussex, the Isle of Wight, &c. Some bones of the iguanodon would indicate an animal more than 50 feet long.

meleon in the hot regions of South America and in the Antilles, having the property common to chameleons of changing its colour, but it is a more nimble and beautiful animal. In New Holland, where everything is anomalous, there is a lizard with a leaf-shaped tail.

Skinks resemble serpents in form, but with four very short feet and sharp nails on their claws; they burrow in the sands of Africa and Arabia: there is a species of gigantic black and yellow skink in New Holland, and those in the islands of the Indian Archipelago are green, with blue tails.

Two anomalous saurians of the genus Amblyrhinchus were discovered by Mr. Darwin in the Galapagos Archipelago. One found only in the central islands is terrestrial, and in many places it has undermined the ground with its burrows; the other is the only lizard known that lives on sea-weed and inhabits the sea; it is about four feet long, and hideously ugly, with feet partially webbed and a tail compressed laterally. It basks on the beach, and in its marine habits and food it resembles, on a small scale, the huge monsters of a former creation.

Tortoises are covered with a shell or buckler, but their head, legs, and tail are free, covered with a wrinkled skin, and the animal can draw them into the shell when alarmed. The head is sometimes defended by a regular shield, and the jaws, instead of teeth, have a horny case. The upper buckler is rounded, and formed of eight pairs of plates symmetrically disposed, and often very beautiful; the

under shell is flat, and consists of four pair of bones and one in the centre. One family of tortoises is terrestrial, two others are amphibious, one of which lives in fresh water, the other in tropical and warm seas.

There are more land tortoises in Africa than in all the rest of the world, both specifically and individually. They abound also in the great Sunda Islands, in the United States of America, South America, and especially Brazil. There are a few European species, of which the common tortoise (Testudo Græca), which is found in all the countries round the Mediterranean, is the largest, being about a foot long; it lives on insects and vegetables, and burrows in the ground in winter. Some of the East Indian species are enormously large, above three feet long, and remarkable for the beautiful distribution of their colours; certain species are peculiar to Brazil, one to Demerara, and one to North America; but perhaps the largest known species is that of the Galapagos Islands, the Testudo Indicus, which attains 500 or 600 pounds in weight.

There are two families of the fresh-water tortoises that live in ponds and ditches. The emys is very numerous in America; there are 15 species peculiar to the northern part of the continent, and four to the southern: only one has been found in Africa, two in Europe, and eight in Asia. The Emys caspia, in Asia Minor, follows a leader, and plunges into the water when alarmed. The Chelydæ are found in the South American rivers.

The trionyx, or fresh-water turtle, lives in the great rivers and lakes in warm countries; there are two species peculiar to North America; they are very large and voracious, devouring birds, reptiles, and young crocodiles, and often are a prey to old ones. One is peculiar to the Nile, one to the Euphrates; there are four species in the Ganges, which are constantly seen eating the bodies of the natives that are thrown into the sacred stream; one of these turtles often weighs 240 pounds. The starred trionyx is in the rivers of Java only, and another kind is common also to the rivers of Borneo and Sumatra.

The Chelonians, or sea-turtles, live in the seas of the torrid and temperate zones, to the 50th parallel of latitude, some eating algæ, and others small marine animals. Different species are found in different parts of the ocean. The green turtle, of which there are many varieties, inhabits the intertropical Atlantic; they may be seen eating seaweed at the bottom of the water along the coasts, and they come in great shoals to the mouths of rivers to lay their eggs in the sand from distances of many hundred miles. This turtle is often six or seven feet long, and weighs 600 or 700 pounds; it is much esteemed for food, but the shell is of no value.

The hawk's-bill turtle, which yields the tortoiseshell, is caught among the Molucca Islands, and on the north-western coast of New Guinea. There is also a fishery in the western hemisphere at Haiti and the Caiman Islands, but the shell is less valuable than

that from the east. There are two species in the Mediterranean, which are only valued for the oil.

With respect to the whole class of reptiles it may be observed, that not one species is common to the Old and New World, and few are common to North and South America; those in New Holland are altogether peculiar; and, as far as is at present known, with the exception of the Marianne Islands, there are neither toads, frogs, nor snakes in any of the islands of Oceanica, though the Indian Archipelago abounds in them; neither are they found in Tierra del Fuego, in the Straits of Magellan, nor in the Falkland Islands.

Five species of reptiles only appear to have existed in Ireland before its geological separation from England—a lizard, a frog, a toad, and two tritons.

CHAPTER XXXI.

Distribution of Birds in the Arctic Regions — In Europe, Asia, Africa, America, and the Antarctic Regions.

More than 6000 species of birds are known, which are arranged in six natural orders or groups, namely, Birds of prey—or vultures, eagles, hawks; Climbers, including parrots and woodpeckers; Songsters, the most numerous of all the six; Gallinaceous birds, including our domestic fowls, partridges, grouse, and pheasants; Waders—herons, snipes, curlews; and Swimmers, or web-footed birds. Next to tropical America, Europe is richest in species: the greatest number of birds of prey inhabit Europe and America, which last surpasses every country in the number of songsters and climbers.

There is great similarity in the birds of the northern parts of the old and new continents, and many are identical. Towards the south, the forms differ more and more, till in the tropical and south temperate zones of Asia, Africa, and America they become entirely different, whole families and genera often being stationary within very narrow limits. Some birds, however, are almost universal, especially birds of prey, waders, and sea-fowl.

The bald buzzard is to be met with in every country from Europe to Australia; the Chinese gosshawk inhabits the American continent, and every station

between China and the west coast of Europe; the peregrine falcon lives in Europe, America, and Australia; the common and purple herons are indigenous in the old continent and the new; and the flamingo of different species fishes in almost every tropical river, and in the Andes to the height of 13,000 feet. Many of the sea-fowl also are widely spread: the wagel-gull is at home in the northern and southern oceans. Captain Beechey's ship was accompanied by pintadoes, or Cape pigeons, during a voyage of 500 miles in the Pacific; and even the common house-sparrow is as much at home in the villages in Bengal as it is in Britain. Many more instances might be given, but they do not interfere with the general law of special distribution.

Birds migrate to very great distances in search of food, passing the winter in one country and the summer in another, many breeding in both. In cold climates insects die or hybernate during winter; between the tropics they either perish or sleep in the dry season: so that, in both cases, insect-eating birds are compelled to migrate. When the ground is covered with snow, the want of corn and seeds forces those kinds whose food is vegetable to seek it elsewhere; and in tropical countries the annual inundations of the rivers regulate the migrations of birds that feed on fish.

Some migrate singly, some in groups, others in flocks of thousands; and, in most instances, the old and the young birds go separately. Those that fly in company generally have a leader, and such as fly

in smaller numbers observe a certain order. Wild swans fly in the form of a wedge, wild geese in a line. Some birds are silent in their flight, others utter constant cries, especially those that migrate during night, to keep the flock together, as herons, goat-suckers, and rails.

Birds of passage in confinement show the most insurmountable disquietude when the time of migration draws near. The Canadian duck rushes impetuously to the north at the usual period of summer flight. Redbreasts, goldfinches, and oriols, brought from Canada to the United States when young, dart northwards, as if guided by the compass, as soon as they are set at liberty. Birds return to the same place year after year. Storks and swallows take possession of their former nests, and the times of their departure are exact even to a day. Various European birds spend the winter in Asia and Africa; while many natives of these countries come to central Europe in summer.

The birds of passage in America are more numerous, both in species and individually, than in any other country. Ducks, geese, and pigeons migrate in myriads from the severity of the northern winters; and when there is a failure of grain in the south, different families of birds go to the north. The Virginian partridge crosses the Delaware and goes to Pennsylvania when grain is scarce in New Jersey; but it is so heavy on the wing, that many fall into the river, and end the journey by swimming. The same thing happens to the wild turkey,

which is caught in hundreds as it arrives wet on the banks of the Ohio, Missouri, and Mississippi. These birds are not fitted for long flight by their structure, because their bones have fewer of those air-cells which give buoyancy to the feathered tribes. The number of air-cells is greatest in birds that have to sustain a continued and rapid flight; probably the extremes are to be met with in the swift and the ostrich—the one ever on the wing, the other never. The strength of the ostrich is in the muscles of its legs; while the muscles on the breast of the swift weigh more than all the rest of the body: hence it flies at the rate of 100 miles an hour easily. The wild duck and the wild pigeon fly between 400 and 500 miles in a day. The stork and some other migratory birds do not halt till the end of their journey. Many sea-fowl are never seen to rest; and all the eagles, vultures, and hawks are birds of strong flight, and capable of sustaining themselves at heights beyond the reach of less buoyant creatures.

DISTRIBUTION OF ARCTIC AND EUROPEAN BIRDS.

The birds of Europe and North America are better known than those of any part of the globe. New species are constantly discovered in Asia, Africa, and South America; and extensive regions in the East are yet unexplored: however, about 6000 have already been described.

There are 503 species of birds in Europe, many

of which are distributed over Asia and Africa, without any apparent variation; and 100 of our European species are also in North America. Of these 39 are land-birds, 28 waders, and 62 water-fowl; among which are most of the marine birds of northern Europe, which, like all sea-fowl, have a wider range.

More than three-fourths of the species, and a much larger proportion of individuals, of the birds of Greenland, Iceland, and Feroe, are more or less aquatic, and many of the remainder are only occasional visitors. Of the few small birds, the greater number are British; but many that reside constantly in Britain are migratory in Iceland and Feroe, and all the small birds leave Greenland in winter. The Aquila albicilla, or fishing eagle, is the largest bird of these northern islands; it feeds on salmon and trout, and builds its nest on the boldest crags. The jer-falcon, or Falco Islandicus, though native, is rare even in Iceland. The snowy owl lives near the glaciers in the interior of Greenland, and is sometimes seen in Orkney. Particular kinds of grouse are peculiar to high latitudes, as the ptarmigan or white grouse. The Columba æneas lives on all the rocky coasts of Europe, and it is also an American bird. The crow family are inhabitants of every part of the globe. The common crow is very generally distributed; the carrion-crow and jackdaw are all over Europe and North America. The Royston crow is the only one of the genus within the Arctic circle, and but a summer visitor. The mag-

pie is everywhere in Europe. The Jay, one of the most beautiful birds of its tribe, is found in Europe, North America, and China. The raven is everywhere, from Greenland to the Cape of Good Hope, and from Hudson's Bay to Mexico; it is capable of enduring the extremes of heat and cold, and is larger, stronger, and more ravenous in the Arctic islands than anywhere else. It is said to destroy lambs, and to drive the eider-ducks from their nests to take their eggs or young: they unite in flocks to chase intruding birds from their abode.

Waders are more numerous than land-birds in the Arctic regions. The snipe and the golden plover are mere visitors; and the oyster-catcher remains all the year in Iceland: it makes its nest near streams, and wages war with the crow tribe. The heron, curlew, plover, and most of the other waders, emigrate; sand-pipers and the water-ousel remain all the year round.

Web-footed birds, being clothed with down and oily feathers, are best able to resist the cold of a polar climate. The Cygnus musicus, or whistling swan, is the largest migratory bird of Europe or America. It is 5 feet long from the tip of the bill to the end of the tail, and 8 feet from tip to tip of the wings: its plumage is pure white, tinged orange or yellow on the head. Some of them winter in Iceland; and in the long Arctic night their song is heard, as they pass in flocks: it is like the notes of a violin. Various species of the duck tribe live in the far north, in prodigious multitudes. The

mallard, supposed to be the origin of our tame duck, is everywhere in the Arctic lands. There are two species of eider-duck: the king duck, or Somateria spectabilis, one of these, is widely dispersed over the islands and coasts of the North Atlantic, and all the Arctic land and islands in Europe and America. In Europe its most southern building-place is the Fern Islands on the coast of Northumberland; in America it never goes south of New York. It lives in the open sea in winter, and resorts to the coast when the grass begins to grow. The duck makes her nest of sea-weed, lined with down from her breast. The islanders take the eggs and down twice in the season; but they do not kill the old birds, because the down of a dead duck is of no value, having lost its elasticity. The third time the drake repairs the nest with down from his breast: the birds are allowed to hatch their brood; and, as soon as the young can feed themselves, they are taken out to sea by the duck. They attain maturity in 4 years, and then measure 2 feet from tip to tip of the wing. The same couple has been known to frequent a nest 20 years, and the Icelanders think the eider-duck lives to 100.

The cormorant, which lives on fish, is universal in the northern seas, and is scarcely ever eaten by the natives. It sits singly, or sometimes in flocks, on the rocks, watching the fish with its keen eye: it plunges after them, and pursues them for three or four minutes under water. Auks are very numerous, especially the razor-billed auk, or penguin; but the great auk,

which is incapable of flight with its little wings, is now nearly extinct in the Arctic islands. The tern, or sea-swallow, is seen everywhere in these seas, skimming along the surface of the water, catching molluscas and small fish. Gulls of many species, and in countless numbers, are inhabitants of the Arctic regions, whilst in the Antarctic they are represented by the equally numerous genus of Procellaria, of which the Mother-Cary's-chicken or stormy petrel is the type. No birds are more widely dispersed than these two genera. They are at home, and brave the storm, in every latitude and in every sea; but those in the north are said to be larger and more numerous than elsewhere. There are nine or ten species in the Arctic regions, and the most numerous of these probably are the kittywakes, the young of which cover the rocks in Iceland, packed so close together that 50 are killed at a shot.

The skua is one of the boldest and most rapacious of birds, forming a link between gulls and birds of prey. It lives by robbing other birds, and is so audacious that it forces the gulls to disgorge the fish they have swallowed, and has been seen to kill a puffin at a single blow. Its head-quarters are in Feroe, Shetland, and the Hebrides, where it hatches its brood, and attacks animals if they come near them.

A few species of petrel inhabit the Arctic seas, but the South Pacific and the Antarctic seas are the favourite resort of this genus. They take their name from the faculty they have of walking on the

water,[1] which they do by the aid of their flat webbed feet and widely-extended wings. The stormy petrels, consisting of several distinct species, confounded by sailors under the name of tempest-bird or Mother-Cary's-chicken, are the most widely diffused, about the size of a swallow, and nearly of the same colour as the latter; their flight is rapid; they shelter themselves from the storm in the hollow of a wave, and go to land only at the breeding season.

It is observed that all birds living on islands fly against the wind when they go to sea, so as to have a fair wind when they return home tired. The direction of the prevailing winds, consequently, has great influence on the choice of their abode: for example, the 25 bird-rocks, or Vogel-berg, in Feroe, face the west or north-west; and no bird frequents the cliffs facing the east, though the situation is to all appearance equally good; a preference accounted for by the prevalence of westerly wind in these latitudes.

Most marine birds are gregarious. They build their nests on the same rock, and live in society. Of this a curious instance occurs on the rocks in question. The Fugle-berg lies in a frightful chasm among the cliffs of Westmanshavn in Feroe. The chasm is encompassed by rocks 1000 feet high, and myriads of sea-fowl cluster round the top of the crags; but different kinds have separate habitations; and no race or individual leaves his own quarters, or ventures to intrude upon his neighbours.

[1] Petrel, from St. Peter.

Upon some low rocks, scarcely rising above the surface of the water, sits the glossy cormorant; the predatory skuas, on a higher shelf, are anxiously regarded by myriads of kittywakes on nests in crowded rows along the shelving rock above, with nothing visible but the heads of the mothers almost touching one another; the auks and guillemots are seated a stage higher on the narrow shelves, in order as on a parade, with their white breasts facing the sea, and in absolute contact. The puffins form the summit of this feathered pyramid, perched on the highest station, and scarcely discernible from its height, if they did not betray themselves by flying backwards and forwards. Some of these tribes have a watch posted to look out for their safety; and such confidence has the flock in his vigilance, that if he is taken the rest are easily caught. When the whole take flight, the ear is stunned by their discordant screams.

The greater part of the marine birds of the Arctic seas are inhabitants also of the northern coasts of the continent of Europe and of the British islands.

No part of Europe is richer in birds than Britain, both in species and numbers of individuals; and the larger game is so abundant, that no one thinks of eating nightingales and redbreasts. Of the 503 species of European birds, 277 are native in our islands. The common grouse, the yellow and pied wagtails, and the English starling, are found nowhere else. It is probable that most of the British birds came from Germany before the separation of our island from the continent, and many of short

flight never reached Ireland. The ptarmigan and capercailzie came from Norway.

There are five European vultures: the lemmergeyer of the Alps and Pyrenees builds its nest in the most inaccessible parts of the mountains, and is seldom seen; it lives also in the mountains of Abyssinia and on the Mongolian steppes. Ten eagles are European; one is peculiar to Sardinia; and several of them are common in America: the golden eagle is one; that beautiful bird, which once gave a characteristic wildness to our Scotch mountains, and the distinguishing feather to the bonnet of our chieftains, is now nearly extirpated. The osprey or fishing eagle is equally an inhabitant of Europe and America, and so are some of our numerous hawks; among others the jer or gentil falcon has been so much destroyed, that it is now rare even in Iceland, its native place: there are still a few in Scotland, and several are caught in their migratory flight over the Low Countries and reclaimed by the expert falconers for the now nearly obsolete sport of falconry.

The owl tribe is numerous, and many of them are very handsome. The Bubo maximus, the great owl, the largest of nocturnal birds, inhabits the forests of middle and southern Europe; it is rare in France and England, though not uncommon in Ireland and Orkney: in Italy a small owl is tamed and used as a decoy.

Owls, eagles, and hawks have representatives in every country, but of different species. The two species of European Goatsuckers migrate to Africa in winter; their peculiar cry may be heard on

a moonlight night when a large flock takes wing for the journey. Several of our swallows go to Africa: both our kingfishers are African, and only visit us in summer; one, the Alcedo ispida, is a native of Lower Egypt and the shores of the Red Sea. Some of the 7 species of European creeping birds, or certhias, creep on the trunks and branches of trees in search of insects; others pursue their prey clinging to the face of rocks and walls, supported by the stiff elastic feathers of the tail: the hoopoe, an inhabitant of southern Europe, is also a creeper, but it pursues small reptiles and insects on the ground.

The Fringillæ or thick-billed birds are by much the most characteristic of Europe; to them belong our finest songsters. The sylvias have soft beaks, and feed on insects and worms; the nightingale, the redbreast, the wren, the smallest of European birds, the warblers, white-throat, and others are of this family. Thick-billed birds live on seed, as the common sparrow, the gold and other finches, linnets, buntings, and crossbeaks.

Four species of fly-catchers are peculiar to Europe, and five species of shrikes. Ravens, crows, jays, and magpies are everywhere; the Alpine crow and nutcracker are found in central Europe only. Compared with America the starling family is poor, and the woodpecker race still more so, yet we have six species, some of which are very beautiful. There is only one cuckoo entirely European, the other two kinds only come accidentally, and all are birds of passage. There are four species of the pigeon tribe;

the ringdove frequents the larch forests, and is migratory; the stockdove also leaves us in October; the biset or rock pigeon, supposed to be the origin from which the infinite variety of our domestic pigeons has sprung, flies in flocks, and makes its flimsy nest on trees and rocks; it is also found in the Da-ouria part of the Altaï chain. Of gallinaceous birds there are many; the only native pheasant is in the south-western parts of the continent; and the capercailzie, extinct in the British forests, inhabits many parts of Europe; in Scandinavia especially it is plentiful as far as the pine-tree grows, which is nearly to North Cape, and also in the Russian forests. The hazel grouse frequents the pine and aspen forests in central and northern Europe, where the black cock also is plentiful. Five species of grouse and six of partridges afford abundance of game; four of the latter are confined to the southern parts of the continent, and so are the sand and pen-tailed grouse, which form a separate family; the former inhabits the sterile plains of Andalusia and Granada, and the latter the stony uncultivated parts of France, southern Italy, and Sicily. The Ortigis Gibraltarica is a peculiar bird allied to the grouse family, found in the south of Europe only.

European waders are very numerous, and among them there are specimens of all the genera; woodcocks, snipes, plovers, curlews, and grebes, are very abundant, and herons of various species; three of them are egrets or crested herons, and the common heron now assembles on the tops of trees unmolested,

since the progress of agriculture has rendered the country unfit for hawking. Several cranes and storks, and two species of ibis, are European: a species of flamingo is met with in the south-eastern parts of the continent, and in the maremme on the east coast of Italy. Many of the waders, however, migrate in winter. The stork, so great a favourite in Holland that it is specially protected, is a wanderer; it retires to Asia Minor, and on the return of summer resumes its old nest on a chimney-top, breeding in both countries. About 139 species of European birds either live in the more elevated parts of the Alps, or cross them in their annual migrations. They generally take their flight by the great St. Bernard, the pass of St. Theodule, the Simplon, and St. Gothard. Europe is particularly rich in web-footed birds; there are three species of wild swans, four of wild geese, and more than 30 of the duck tribe, including the inhabitants of the Arctic seas.

BIRDS OF ASIA AND THE INDIAN ARCHIPELAGO.

European birds are widely spread over Asia; most of the Arctic sea-fowl frequent its northern coasts: between 50 and 60 European birds are also Siberian, and there are above 70 European species in Japan and Corea, which probably are also inhabitants of Siberia and the Altaï Mountains, and several are identical with the birds of North America; so that the same affinity prevails in the feathery tribes of the Arctic regions as in the vegetable productions.

Asia Minor is a country of transition, and many European birds are mixed with those of warmer regions, as the Halcyon smyrnensis, a large bird with gorgeous plumage, identical with the great Bengal kingfisher, general throughout India. European birds also inhabit the Caucasus, the shores of the Caspian Sea, and Persia. Moreover these warmer climates are the winter-quarters of various European species.

In Asia Minor, and especially in Armenia, the number and variety of birds is very great; large eagles, vultures, falcons, buzzards, quails, partridges, starlings, herons, storks, cranes, legions of Arctic grebes, swans, wild geese, ducks, and pelicans, are natives of these countries; besides singing-birds, the nightingale, the constant theme of the poet's song, abounds in Persia: hawks are trained for hunting deer in that country, and the Asiatic partridges, or francolins, more vividly coloured than ours, differ also in having beaks fitted for digging up bulbous roots, which is their food in the deserts.

Farther east the types become more Indian; the great peninsulas on each side of the Ganges are the habitations of the most peculiar and the most gorgeous of birds. Many species, and some entire genera, of kingfishers are here, of the gaudiest colouring; the plumage of the fly-catchers has the richest metallic lustre; and the shrikes, of a sober hue with us, are there decked in the brightest colours; the drongo has a coat of ultramarine, and the calyptomene has one of emerald green.

The large-beaked climbing-birds are singularly handsome. The great green parrot, so easily taught to speak, has inhabited the Indian forests and the banks of the Ganges time out of mind, with a host of congeners of every colour; not one species of these, or indeed of the whole parrot tribe, is common to Asia, Africa, America, or Australia, nor even to any two of these great continents. They are vividly coloured in India, but the cuckoo tribe rivals them; several genera of these birds exist nowhere else, as the large-beaked Malcahos, the Coucals with their stiff feathers, and the Couroucous or Trogons, dressed in vermilion and gold; the last, however, also inhabit other tropical climates.

Eastern Asia is distinguished by the variety of its gallinaceous birds and the gorgeousness of their plumage. To this country we owe our domestic fowls; and two species of peacock are wild in the woods of India and Ceylon. The Polyplectron, the only bird of its kind, and the Tragopons, are Indian; and some of the most brilliant birds of the East are among the pheasant tribe, of which five species are peculiar to China and Tibet. There are various species of the pheasant in the Himalaya, and one whose feathers have a metallic lustre. The gold, the silver, and Reeves' pheasant, the tail-feathers of which are four feet long, belong to China. The Lophophorus refulgens, and some others of that genus, are altogether Indian.

The pigeons also are very splendid in their plu-

mage; they mostly belong to China and Japan; those in the Birman empire are green.

It would be vain to enumerate the fine birds that range in the forests, or fish in the rivers, of the Asiatic continent, yet the birds of the Indian Archipelago far surpass them in splendour of plumage; these islands indeed are the abode of the most gorgeously arrayed birds in existence. Even in Java and Sumatra, though most similar to India in their winged inhabitants, there are many peculiar, especially 12 or 13 species of the climbing tribe, and several of the honey-sucking kind; but the dissimilarity increases with the distance, as in New Guinea and its islands, where the honey-sucking genera are developed in novel forms and sumptuous plumage.

In the various islands of the archipelago there are altogether at least 15 genera, with their numerous species, found there only. There are the Cassicans, which resemble jays, with plumage of metallic lustre; the only two species of Pirolls, one bright violet, the other of brilliant green; various species of Buceros with large horned beaks, Oriols of vivid colours, the swallow that builds the edible nest, the most numerous and splendid Sylvias, and all the species but one of the Philedons or honey-sucking birds with tongues that end in a brush. Birds of Paradise of many kinds inhabit New Guinea and the neighbouring Moluccas and Aroo Islands. They are birds of passage, and change their quarters with the monsoon. The king bird of paradise

has two long slender filaments from the tail, ending in a curled flat web of emerald green, and the male of the green species has long flowing plumes from the sides of his body, which give him a magnificent appearance. The pigeons are peculiarly beautiful and numerous, but limited in their abode. The Gouroa, or great crowned pigeon, the largest of its tribe, is an inhabitant of Borneo. Each island has its own species of Louries, which exist nowhere else; many peculiar paroquets and cockatoos, couroucous or trogons, coucals, and the barbu, with huge beaks, are all peculiar to these islands. Even the partridges have thrown aside their grave colours and assumed the vivid hues of the tropics, as the green and tufted Cryptonyx. But the other gallinaceous birds far surpass them, as the fire and the Argus pheasant, and two or three species still more splendid, with a host of other birds already known, and multitudes which Europeans never have seen, in the deep jungles and impenetrable forests of these unexplored islands. The Cassowary, a bird akin to the ostrich, without the power of flying, but fleet in its course, has a wide range in the Indian Archipelago and the south-eastern peninsula of Asia, and, though destitute of beauty, is interesting from its peculiar location and the character of the whole race.

AFRICAN BIRDS.

A great number of European birds are also inhabitants of Africa, and many migrate there in winter,

yet the birds of this continent are very peculiar and characteristic; those in the north and north-east, and at the Cape of Good Hope, are best known, but the greater part of tropical Africa is still unexplored. It may be observed, generally, that the tropical birds differ from those of north Africa, but are, with a few exceptions, the same with those in the southern part of the continent, and the whole of Africa south of the desert differs in species from those of north and western Africa and from Europe. Moreover, there is a strong analogy, though no affinity, between the birds of Africa and America in the same parallels of latitude; there is not a single perching bird common to the two, though some of the rapacious are in both.

There are 59 species of birds of prey, of which a few are also European. The Secretary-bird is the most singular of this order: it preys upon serpents at the Cape of Good Hope, in Abyssinia, and other parts of the continent. Africa possesses at least 300 species of the passerine order, of which 10 genera, with all their species, are peculiarly its own. The swallows are more beautiful than ours, especially the Cecropis striata, with two tail-feathers twice as long as its body. Many kingfishers, the most beautifully coloured of their brilliant race, frequent the lakes and rivers: four species of Hoopoes, one of which visits Europe in summer, are natives; and the honey-birds, the representatives of the humming-birds of South America, are peculiarly African. They abound at the Cape of Good Hope,

where the nectaries of proteas and other plants produce the saccharine juice which is their food. The Malurus Africanus, and many other singing-birds for the most part unknown elsewhere, inhabit the forests. The canary-bird is confined to the Canary Islands; its song differs even in two adjacent districts: there are, however, other instances of this. The Capirote, also indigenous in the Canary Islands, is a finer songster, but it cannot be tamed. Various shrikes are peculiar to Africa, but the species known as the grand Baratra is confined to the Azores. There are several birds of the raven tribe, or nearly akin to them: as the Lampratornis superba; another with purple wings, the Buphaga, the only bird of its genus; and several species of the Calaos. The weaving-bird, or Loxia textor, is one of the most remarkable of the graminivorous tribe; it weaves its nest with grass and twigs very dexterously; one brought to Europe wove a quantity of thread among the wires of its cage, with great assiduity, into a strong texture. The Widow-bird, the Calious, the blue bee-eater, and all the fly-catching touracous, with many species of woodpeckers, are found nowhere else. The parrots and paroquets, which swarm in the tropical forests, from the size of a hen to that of a sparrow, are of original forms. The Trogons, or Couroucous, the most beautiful of the large-beaked climbing-birds, are the same as in Asia; but the Barbu and the four species of Barbicans are altogether African, and so are some of the cuckoos. Among the latter are two species of the Cuculus in-

dicator, so named from indicating where the bees have their nests; one is peculiar to Abyssinia, the other to the interior at the Cape of Good Hope; and mocking-birds are spread over a wide extent of this continent.

There are at least 13 species of African pigeons; and to Africa we are indebted for the guinea-fowl, of which there are three or four kinds: it wanders in flocks of hundreds among the brushwood on the banks of rivers and lakes in Numidia and all the tropical regions, and they are even more abundant in Madagascar. Many grouse and partridges are peculiar, especially the Gangas, of which there are five species: some go in coveys, and others traverse the deserts in flocks of many hundreds. The sand-grouse, one of this family, is much more abundant on the arid deserts of north Africa than in Europe; and the partridges of this country are francolins, which feed on bulbous roots.

The ostrich takes the wide range of Africa and Arabia; the bird of the desert, and bustards, also wanderers in the plains, are numerous: the most peculiar are the rhaad and the Otis kori, in south Africa, five feet high, and remarkable for the brilliancy of its eye.

Waders of infinite variety inhabit the rivers, lakes, and marshes—woodcocks, snipes, plovers, storks, cranes, herons, and spoonbills. The most peculiar are the Dromes and Marabous, whose feathers form a considerable article of commerce; the cream-coloured plover, the Scopus or ombrette, the water-treader of

Abyssinia, and the Tantalus tribe, among which is the ibis (Tantalus ibis), held sacred by the ancient Egyptians, so frequently found in mummies in the catacombs, and represented on their monuments.

Swimming-birds are no less numerous: the Bernicla cyanaptera is a goose peculiar to Shoa; the rhynchops and pelicans, several of the duck kind or birds allied to them, are found nowhere else.

BIRDS OF NORTH AMERICA.

Of 471 species of North American birds, about 100 are also found in Europe, the greater number of which are water-fowl, and those common to the northern coasts of both continents. The sea-fowl on the North Pacific and Behring's Straits are very much the same with those in the Greenland seas and the North Atlantic, but the great Auk or penguin, with featherless wings, still exists on the North Pacific, and the large white albatross, seldom seen in the North Atlantic, frequents Behring's Straits and the western coasts of North America in immense flocks. It is almost universal in the Pacific and in the stormy regions towards the southern pole. Like the Mother-Cary's-chicken, it is a bird of the tempest, sailing calmly on its huge wings in the most tremendous gales, and following a ship a whole day without resting on the waves: it is the largest of winged sea-fowls; some measure 14 feet from tip to tip of the wings.

There is no vulture common to the two continents,

but there are five eagles, half of the other birds of prey, a fourth part of the crow tribe, several waders and web-footed birds which inhabit both; yet the general character of North American birds is different from that of European: 81 American generic forms and two families are not found in Europe. The humming-birds are altogether American; only four species are in North America; one of these is migratory, and another is common to South America. The parrot family, distributed with generic differences in almost all tropical countries, has but one representative here, which lives in the forests of the Carolinas. Europe has nothing analogous to these two families. It is singular that a country with so many rivers and lakes should possess only one kingfisher. The woods are filled with many species of creeping birds, and there are 68 peculiar species of sylvias and fly-catchers; among others the Todus viridis, which forms a genus by itself. Ravens, crows, pies, and jays abound, and there are 13 species of starlings. The finch tribe are very numerous, and there are 16 species of woodpeckers, as might be expected in a country covered with forests. Of pigeons there are eight species, but individually they are innumerable, especially the Columba migratoria, which passes over Canada and the northern States in myriads for successive days twice in the year. The poultry-yard is indebted to North America for the domestic turkey, which there ranges wild in its native woods and attains great size. There are no partridges, properly speaking, and of

13 American species of grouse three are probably European, a family which exists in every country under different forms. The vast expanse of water and marshy ground makes North America the home of water-fowl and waders without end. Most of the waders and graminivorous birds are migratory; in winter they find no food north of the great lakes, where the ground is frozen upwards of six months in the year. Many pass the winter in California, as storks and cranes; wild geese cover acres of ground near the sea, and when they take wing their clang is heard far off. Even gulls and other northern sea-fowl come to the coasts of California, and indeed to the shores of all the north and temperate Pacific.

It may be said generally that, with regard to the web-footed tribe, North America possesses specimens of all the genera of the old world and many peculiarly its own. The table-land of Mexico has some peculiar forms, and some species of swimming-birds found only in more northern latitudes; but, except the Ampelidæ, there are representatives of every group of North and South America.

BIRDS OF SOUTH AMERICA.

The tenants of the air in South America differ more from those in North America than these do from the birds of Europe: there are not more than 50 or 60 species in common. South America has a greater variety of original forms than any other country; more than 25 genera with all their species inhabit that country only; of the passerine family

alone there are at least 1000 species, all peculiar to it. The vultures are of different genera from those in Europe; the Condor of the Andes is the largest of these; it frequents the highest pinnacles of the Andes in summer, and builds its nest at the height of 15,000 feet and more above the sea; and Baron Humboldt saw it wheeling in circles at the elevation of 22,000 feet. It inhabits the Andes from the Straits of Magellan to 7° N. lat., but it never crosses the isthmus of Panama, the condor of California being a smaller bird. It roams over the plains of Patagonia even to the mouth of the Rio Negro, and in winter it descends in groups to feed on the plains and sea-shore; and, like all the vulture race, it possesses the faculty of descrying a dead or dying animal from a very great distance. Although the condor lives principally on dead animals and carrion, it will sometimes attack live animals; its habits are those of our ordinary vulture; much exaggeration has found its way into books as to its size and ferocity; the most remarkable point in its history is the great vertical extent in which it is known to live, from the level of the sea, to an elevation of 22,000 feet. The Vultur papa, or king of the vultures, an inhabitant of the tropical regions, is remarkable for the bright blue and vermilion colour of the head and neck; the black vulture lives in large assemblies on the tops of high trees in the sylvas of Brazil; another numerous species prey on animals in the llanos. Many other rapacious birds are peculiar to this continent; the burrowing owl, so common in the Pampas and

Chile, is one of these. The Guachero forms a genus by itself; it is of the size of a common fowl, with the form and beak of a vulture, and is the only instance known of a nocturnal bird feeding on fruit. It is confined to a limited district in the province of Cumana, and shuns the day: incredible numbers have taken possession of a dark cavern in the valley of Caripe, where they are killed in thousands every year by the Indians for their fat.

The Troupials represent our Oriols, the Baratras and Becardes our shrikes, while the Tangaras partake of the form both of the shrike and pie, which last, with all the rest of the crow family, have various representatives in this country. Swallows, or birds allied to them, are numerous, and many that live on the honeyed juice of flowers, like the humming-bird, so peculiarly characteristic of South America: 150 species of humming-birds, from the size of a wren to that of an humble-bee, adorn the tropical regions of Brazil and Guiana. This family, so entirely American, has a range from the Straits of Magellan to the 38th parallel of N. lat.: it may be met with in the forests on the mountain of Orizaba, at an elevation of 11,000 feet above the sea; and some beautiful species of it at still greater heights in the Andes of Bolivia and New Grenada. There is only one South American humming-bird which is also permanent in the United States, and only two are found in Central America: many of them are migratory; they come in multitudes to north Chile in summer, and disappear in winter. The climbing-

birds, with large bills, are mostly confined to the tropical forests, which swarm with peculiar races of parrots, paroquets, and macaws. It is a remarkable circumstance in the distribution of birds that there should be 40 species of parrots in the torrid zone of America, and only three species on the opposite coast of Africa, though the climate is similar and the vegetation nearly as luxuriant. Parrots range from the Straits of Magellan to the 42nd parallel of N. lat., where the Eider-duck, which is a peculiarly Arctic bird, begins. There are whole families of birds in tropical America not to be seen elsewhere: as the vividly-coloured Toucan, with its huge beak; the Araucari, which lives on the fruit of the Araucaria; some peculiar species of the gorgeous trogons or couroucous; the Tomalias, birds related to the cuckoo tribe; and the Jacmars, which represent the woodpeckers.

The gallinaceous family is totally different from that of the North American forests; the Guan or penelope represents our pheasants, the different species of Crax or Alectors the wild turkey, which they equal in size and brilliancy of plumage; whilst the numerous species of Tinamous and cognate genera fill the place of the grouse, quails, and partridges of the old continent. South America furnishes two species of gallinaceous birds of a very peculiar character—the Cariama of Brazil, like to the secretary-bird of the Cape of Good Hope in its form and its habits of destroying reptiles; and the Kamichi, which possesses one or more sharp triangular spurs at the point of

each wing, a dreadful instrument of attack and defence, such as is possessed by no other bird.

The three-toed or American ostrich, or Struthio Rhea, ranges, like all its congeners, over a wide extent of country. It is found from the silvas of Brazil to the Rio Negro, which bounds the Pampas of Buenos Ayres on the south, and in some of the elevated plains of the Peru-Bolivian Cordilleras; while the Struthio Darwinii has the plains of Patagonia to the Straits of Magellan for its residence.

The water-fowl and waders in this land of rivers are beyond number; millions of flamingoes, spatules, cormorants, herons, fishing falcons, and scissor-beaks, follow the fish that go up the rivers to spawn; nor are gulls wanting where fish are to be found: a little snow-white heron walks on the back and over the head of the crocodile while it sleeps. The water-fowl are almost all peculiar; the few that are excepted are North American. Eight or nine genera belonging to the warm climates of the old world are here under new forms, and the number of specific forms of the same genus is greater than in any other country. The beautiful red Ibis or Tantalus ruber inhabits Cayenne; the Ardea helias and scolopax are the most beautiful of the heron tribe, from their variegated plumage.

Ducks migrate in immense flocks, alternately between the Orinoco and the Amazons, on account of the greater supply of fish afforded by the floods of these rivers, which take place at intervals of six months from each other. Between the tropics the

vicissitudes of drought and humidity have much influence on the migration of birds, because the supply of their food depends upon these changes.

If anything more were required to show the partial location of birds, the Galapagos Archipelago might be mentioned: of 26 specimens shot by Mr. Darwin, 25 were peculiar, though bearing a strong resemblance to American types; some birds were even confined to particular islands; and the gulls, one of the most widely dispersed families, are peculiar. But on this comparatively recent volcanic group, only 500 miles distant from the coast of America, everything is peculiar—birds, plants, reptiles, and fish; and though under the equator, none have brilliant colours.

The coasts of Peru and northern Chile are not rich in birds, but in southern Chile there are many humming-birds, parrots, flamingoes, peculiar ducks and geese; and there commences that inconceivable quantity of sea-fowl that swarm on the seas and coasts of the Antarctic regions. The black scissor-bill, or Rhynchops nigra, has been seen to form a dense mass seven miles long; shags fly in an unbroken line two miles. Pelicans, terns, petrels, and many others cover the low islands and coasts of the mainland, and those of Tierra del Fuego.

In the Antarctic and Southern seas Petrels take place of our gulls; seven species of them inhabit these high southern latitudes in prodigious numbers. Two remarkable species of this genus are found throughout the Southern Ocean—the Giant Petrel

(P. Gigantea), equal to the albatross in size, and resembling it in its mode of life—it sometimes becomes perfectly white; and the Equinoctial Petrel (P. Equinoctialis), a beautiful bird as large as our domestic fowl, and of a jet black colour. A flock of what was supposed to be the young of the species known as the Pintado or Cape pigeon (Procellaria Capensis) was estimated to have been from six to ten miles long, and two or three miles broad, absolutely darkening the air during the two or three hours they were flying over the Discovery ships. The snowy petrel, a most elegant bird, never leaves the ice, and consequently is never seen north of the Antarctic circle in summer. Three species of the southern Penguin (Aptenodytes) inhabit these seas; the A. Patachonica, the largest of sea-fowls, is a rare and, for the most part, solitary bird, lives on the pack-ice, and weighs from 60 to 70 pounds. The other two species are smaller and gregarious; they crowd the snow-clad islands in the high southern latitudes in myriads; every ledge of rock swarms with them, and on the shore of Possession Island, close to Victoria Land, it was difficult to pass through the multitudes. They are fine, bold birds, pecking and snapping with their sharp bills at those who venture among them. They can scarcely walk, and, their wings being merely rudimentary, they cannot fly; they skim along the snow, and swim rapidly, even under water, resembling more a fish or a seal than a bird in their movements, and the noise they make baffles all description. Two

species of albatross breed in the Antarctic islands; a kind of skua gull, which robs their nests; and a goose which, like the eider-duck, makes its nest with the down from its breast. A very curious bird, forming as it were a passage between the gallinaceous birds and waders, the Chionis or Vaginalis Alba, is only found near the southern extremity of this continent: it is of a milky white, and of the size of our domestic pigeon, and often takes refuge on the yards of ships off Cape Horn and Staten Land; it lives chiefly on a small species of cuttle-fish. Few land birds are met with within the Antarctic circle: there are but seven or eight species in the Auckland Islands, mostly New Zealand birds; among others, the tooa or tui, and an olive-coloured creeper, the choristers of the woods. One only was found in Campbell Island.

Many generic forms are the same at the two extremities of the globe, yet with distinct specific differences. Sea-fowls are more excursive than other birds, but even they confine themselves within definite limits, so that the coasts may be known from their winged inhabitants.

AUSTRALIAN BIRDS.

The Australian birds are in many respects as singular as the quadrupeds and plants of that country: a white falcon is among its birds of prey, a black swan among its water-fowl, and of 45 genera, 35 are purely Australian. The passeres are so original, that many new genera have been found. The Cassican, a handsome bird of bright colours,

approaching somewhat to the crow family, the Choucalcyon, the golden and black oriole, and one species of Philedon, are peculiarly Australian. The Menura superba, or lyre-bird, from the resemblance its outspread tail bears to the form of the ancient lyre, is the only bird of its genus, and the only one which approaches the character of the gallinaceous family, of which none have been discovered in the Australian continent. Here are many specific kinds of cuckoos, as the Coucal and the Scythrops, the only bird of that genera. Woodpeckers there are none. The parrots, paroquets, and cockatoos, which live in numerous societies, are all peculiar, especially the black cockatoo, which is found here only; it is not so gregarious, but even more suspicious than the white cockatoos, which have a sentinel to warn them of danger. Chious, with huge bills like the toucan satin-birds, pigeons and doves of peculiar forms, abound; and the Cereopsis goose is no less peculiar among the web-footed tribe. The desert plains of this great continent are alloted to the Emu, a large struthious bird, like its congener the cassowary incapable of flight, and once very plentiful, but now in progress of being extirpated or driven by the colonists to the unexplored regions of the interior.

The Apteryx, a bird of the same family, still lingers in New Zealand, but it is on the verge of extinction, and probably owes its existence to its nocturnal and burrowing habits. It is one of those anomalous creatures that partakes of the character of several others; its head is in shape something like that

of the ibis, with a long slender bill, fitted for digging into the ground for worms and grubs; its legs and feet resemble those of the common fowl, with a fourth toe or spur behind, in which it differs from its congeners; and its wings, if wings they can be called, are exceedingly small. In a specimen, whose body measured 19 inches, the wings, stripped of the feathers, were only an inch and a half long, ending in a hard horny claw three inches long. The comparatively small wings are characteristic of the whole family: the rhea and ostrich have the largest, which, though unavailing in flight, materially aid their progress in running; the wings of the emu and apteryx serve only as weapons of defence: the whole tribe also defend themselves by kicking. No animals have a more remarkable geographical distribution than this family, or show more distinctly the decided limits within which animals have originally been placed. These huge birds can neither fly nor swim, consequently they could not have passed through the air or the ocean to distant continents and islands. There are five distinct genera, to each of which very extensive and widely separated countries have been allotted: the Ostrich is spread over Africa, from the Cape of Good Hope to the deserts of Arabia; two species of the Rhea range over the plains of the Pampas and Patagonia, in South America; the continent of Australia is the abode of the Emu; the Cassowary roves over some of the large islands of the Indian Archipelago; and the Apteryx dwells in New Zealand. The Dodo, a very large bird of the

struthious kind, extirpated by the Dutch navigators, once inhabited Mauritius and the adjacent island of Don Rodriguez.

The remains of a very numerous group of extinct struthious birds have been recently discovered imbedded in the very recent geological deposits of New Zealand. One of its genera, the Dinornis, has several species, the largest of which, the D. giganteus, attains a height of 11 feet, or double that of the largest ostrich; another, the Palapteryx, upwards of 9 feet. From the position in which these bones are found, as well as from their state of preservation, they can scarcely be considered as fossil, although belonging to species which have become extinct. Professor Owen has described no less than six species of dinornis, and four of palapteryx; and later discoveries in the colony will probably add several to these numbers. No better example can be cited as elucidating the certitude of the deductions of the comparative anatomist than what led to the first discovery of this extraordinary group of birds. A small portion of a bone, which from its dimensions appeared to have belonged rather to a quadruped of the size of an ox than to a bird, was submitted to Mr. Owen; he boldly pronounced it, from its structure, to belong to a bird of the ostrich kind—a decision that was soon abundantly confirmed by the subsequent discovery not only of the bones of the bird, but of its eggs.

The bones of another extinct bird, the Nestor, have been found, mixed with those of the Dinornis. It had been something between an owl and a parrot,

but more nearly allied to the latter. There are two species living of the nestor, one in New Zealand, another in Philip Island, only five miles in extent, and it is found in no other part of the world. The Notornis, an extinct race, closely allied to the water-hen, of the size of a bustard, had also been an ancient inhabitant of these islands, where birds did and do exist, almost to the entire exclusion of quadrupeds and reptiles: an extinct species of dog, and a rat still existing, are the only land animals which shared in these extensive territories with multitudes of the feathered race.[1]

The ostrich family live on vegetables; the form of those that had their home in New Zealand would lead to the conclusion that they had fed on the edible roots of the fern which covers that country; and as

[1] In some parts of the earth the same conditions which regulated the distribution of the ancient fauna and flora still prevail. The flora of the carbonaceous epoch is perfectly similar to that of New Zealand, where ferns and club-mosses are so abundant; and the fauna of that ancient period had been representative of that which recently prevailed in these islands, since foot-prints of colossal birds have been discovered in the red sandstone of Connecticut.

The age of reptiles of the Wealden and other secondary periods is representative of the fauna of the Galapagos islands, which chiefly consists of tortoises and creatures of the lizard or crocodile family; and the cycadaceous plants and marsupial animals of the oolite are representative of the flora and fauna of Australia.

The colossal birds which prevailed in New Zealand, almost to the entire exclusion of reptiles and quadrupeds, lasted to a very late period; they differed in the structure of the beak and skull from every class of birds, recent or fossil.

no quadruped excepting a rat is indigenous in New Zealand, though 700 miles long, and in many places 90 wide, these birds could have had no enemy but man, the most formidable of all.

The beautiful and sprightly Tui, or parson-bird, native in New Zealand, is jet black with a white tuft on its breast, and so imitative that it can be taught to repeat whole sentences. There are parrots and paroquets, vast numbers of pigeons, fine warblers, many small birds, and a great variety of water-fowl, amongst others a cormorant, which, though web-footed, perches on the trees that overhang the streams and sea, watching for fish; and a snow-white frigate-bird, that pounces on them from a great height in the air. Altogether there are at least 84 species of birds that inhabit these islands.

CHAPTER XXXII.

Distribution of Mammalia throughout the Earth.

Carbonic acid, water, and ammonia, contain the elements necessary for the support of animals, as well as of vegetables. They are supplied to the graminivora in the vegetable food, which is converted into animal substance by their vital functions.

Vitality in animals, as in vegetables, is the power they have of assimilating their food, a process independent of volition, since it is carried on during sleep, and is the cause of force. Animals inhale oxygen with the air they breathe ; part of the oxygen combines with the carbon contained in the food, and is exhaled in the form of carbonic acid gas. With every effort, with every breath, and with every motion, voluntary or involuntary, at every instant of life, a part of the muscular substance becomes dead, separates from the living part, combines with the remaining portion of inhaled oxygen, and is removed. Food, therefore, is necessary to compensate for the waste, to supply nourishment, and to restore strength to the nerves, on which all vital motion depends; for by the nerves volition acts on living matter. Food would not be sufficient to

make up for this waste, and consequent loss of strength, without sleep; during which voluntary motion ceases, and the undisturbed assimilation of the food suffices to restore strength, and to make up for the involuntary motion of breathing, which is also a source of waste.

The perpetual combination of the oxygen of the atmosphere with the carbon of the food, and with the effete substance of the body, is a real combustion, and is supposed to be the cause of animal heat, because heat is constantly given out by the combination of carbon and oxygen; and, without a constant supply of food, the oxygen would soon consume the whole animal, except the bones.

Graminivorous animals inhale oxygen in breathing, and, as vegetable food does not contain so much carbon as animal food, they require a greater supply to compensate for the wasting influence of the oxygen; therefore, cattle are constantly eating. But the nutritious parts of vegetables are identical in composition with the chief constituents of the blood; and from blood every part of the animal body, and even a portion of the bones, is formed.

Carnivorous animals have not pores in the skin, therefore their supply of oxygen is from their breath only; and, as animal food contains a greater quantity of carbon, they do not require to eat so often as animals that feed on vegetables. The restlessness of carnivorous animal when confined in a cage is owing to the superabundance of carbon in their food. They move about continually to quicken respiration,

and by that means procure a supply of oxygen to carry off the redundant carbon.

The quantity of animal heat is in proportion to the amount of the oxygen inspired in equal times. The heat of birds is greater than that of quadrupeds, and in both it is higher than the temperature of amphibious animals and fishes, which have the coldest blood. On these subjects we are indebted to Professor Liebig, who has thrown so much light on the important sciences of animal and vegetable chemistry.

The mammalia consist of nine orders of animals, which differ in appearance and in their nature; but they agree in the one attribute of suckling their young. These orders are—the Quadrumana, animals which can use their fore feet as hands, as monkeys and Apes; Cheiroptera, animals with winged arms, as bats; Carnivora, that live on animal food, as the lion, tiger, bear, &c.; Rodentia, or gnawers, as beavers, squirrels, mice; Edentata or toothless animals,[1] as anteaters and armadilloes; Pachydermata, or thick-skinned animals, as the elephant, the horse; Ruminantia, animals that chew the cud, as camels, lamas, giraffes, cows, sheep, deer; Marsupialia, possessing a pouch in which the young is received after birth; and Cetaceæ, as whales and dolphins.

The animal creation, like the vegetable, varies correspondingly with height and latitude; the changes of species in ascending the Himalaya, for instance,

[1] Or more properly wanting certain teeth, as the canines or incisors.

are similar to what a traveller would meet with in his journey from a southern to a high northern latitude. The number of land animals increases from the frigid zones to the equator, but the law is reversed with regard to the marine mammalia, which abound most in high latitudes. Taking a broad view of the distribution of the nine orders of mammalia, it may be observed that the tropical forests are the chief abode of the monkey tribe: Asia is the home of the ape, especially the islands of the Indian Archipelago, as far as the most easterly meridian of Timor, beyond which there are none.

They abound throughout Africa from the Cape of Good Hope to Gibraltar, where the Barbary ape or magot is found: another species of magot inhabits the island of Niphon, the northern limit of monkeys at the eastern extremity of the continent.

The bats that live on fruits are chiefly met with in tropical and warm climates, especially in the Indian Archipelago; the common bats, which live on insects, and are so numerous in species as to form more than a third of the whole family, are found everywhere except in arctic America. The Vampire is only met with in tropical America. Carnivorous mammalia are distributed all over the globe, though very unequally: in Australia there are only four species, two of which are bats; there are only 13 in South America, and 27 in the Oceanic region; while in the tropical regions of America there are 109, in Africa 130, and in Asia 166 species of carnivora; and so rapid is their increase towards the

tropical regions, that there are nearly three times as many in the tropical as in the temperate zones.

With regard to the Gnawers or Rodents, species of the same group frequently have a wide range in the same, or nearly the same, parallels of latitude, but when they are inhabitants of high mountain-ridges they follow the direction of the chain, whatever that may be, and groups confined to high latitudes often appear again at great elevations in low latitudes. The Edentata are particularly characteristic of South America, where there are three times as many species as there are in Asia, Africa, and Australia taken together. In the three latter countries they only occur at intervals, but in America they extend from the tropic of Cancer to the plains of Patagonia. Thick-skinned and ruminating animals are very abundant in the old continent, especially in Asia and Africa; they are also in North America, but in the southern part of that continent there is only the Tapir, and in Australia there are none. The marsupialia are confined to Australia and America.

The distribution of animals is guided by laws analogous to those which regulate the distribution of plants, insects, fishes, and birds. Each continent, and even different parts of the same continent, are centres of zoological families, which have always existed there, and nowhere else; each group being almost always specifically different from all others.

Food, security, and temperature have no influence, as primary causes, in the distribution of animals.

The plains of America are not less fit for rearing oxen than the meadows of Europe; yet the common ox was not found in that continent at the time of its discovery; and with regard to temperature, this animal thrives on the llanos of Venezuela and the pampas of Brazil as well as on the steppes in Europe. The horse is another example: originally a native of the deserts of Tartary, he now roams wild in herds of hundreds of thousands on the grassy plains of America, though unknown in that continent at the time of the Spanish invasion. All animals, however, are not so flexible in their constitutions, for most of them would perish from change of climate. The stations which the different families now occupy must have been allotted to them as each part of the land rose above the ocean; and because they have found in these stations all that was necessary for their existence, many have never wandered from them, notwithstanding their powers of locomotion; while others have migrated, but only within certain bounds.

Instinct leads animals to migrate when they become too numerous: the rat in Kamtchatka, according to Pennant, sets out in spring in great multitudes, and travels 800 miles, swimming over rivers and lakes; and the Lapland marmot or lemming, native in the mountains of Kolen, migrates in bands, once or twice in 25 years, to the Western Ocean, which they enter and are drowned; other bands go through Swedish Lapland and perish in the Gulf of Bothnia. Thus nature provides a remedy against the over increase of any one species, and maintains the

balance of the whole. A temporary migration for food is not uncommon in animals. The wild ass, a native of the deserts of Great Tartary, in summer feeds to the east and north of the lake of Aral, and in autumn they migrate in thousands to the north of India, and even to Persia.[1] The ruminating animals that dwell in the inaccessible parts of the Himalaya descend to their lower declivities in search of food in winter; and for the same reason the reindeer and musk-ox leave the Arctic snows.

The Arctic regions form a district common to Europe, Asia, and America. On this account, the animals inhabiting the northern parts of these continents are sometimes identical, often very similar; in fact, there is no genus of quadrupeds in the Arctic regions that is not found in the three continents, though there are only 27 species common to all, and these are mostly fur-bearing animals. In the temperate zone of Europe and Asia, which forms an uninterrupted region, identity of species is occasionally met with, but for the most part marked by such varieties in size and colour as might be expected to arise from difference of food and climate. The same genera are sometimes found in the intertropical parts of Asia, Africa, and America, but the same species never; much less in the south tem-

[1] Perhaps no quadruped in the wild state will be found to have so wide a vertical range of habitat as this animal. It is found in the plains of Tartary, in the valley of the Tigris, at a very few feet above the sea-level, and in the most elevated plains of the Himalaya, at elevations exceeding 15,300 feet.

perate zones of these continents, where all the animals are different, whether birds, beasts, insects, or reptiles; but in similar climates analogous tribes replace one another.

Europe has no family and no order peculiarly its own, and many of its species are common to other countries; consequently the great zoological districts, where the subject is viewed on a broad scale, are Asia, Africa, Oceanica, America, and Australia; but in each of these there are smaller districts, to which particular genera and families are confined. Yet when the regions are not separated by lofty mountain-chains, acting as barriers, the races are in most cases blended together on the confines between the two districts, so that there is not a sudden change.

EUROPEAN QUADRUPEDS.

The character of the animals of temperate Europe has been more changed by the progress of civilization than that of any other quarter of the globe. Many of its original inhabitants have been extirpated, and new races introduced; but it seems always to have had various animals capable of being domesticated. The wild cattle in the parks of the Duke of Hamilton and the Earl of Tankerville are the only remnants of the ancient inhabitants of the British forests, though they were spread over Europe, and perhaps were the parent stock from which the European cattle of the present time have descended;

though the Aurochs, a race nearly extinct, and found only in the forests of Lithuania and the Caucasus, may have some claim to the pedigree. Both races are supposed to have come from Asia. The Mouflon, which exists in Corsica and Sardinia, is said to be the parent stock of our domestic sheep. The pig, the goat, the fallow-deer, and red-deer, have been reclaimed, and also the reindeer, which cannot strictly be called European, since it also inhabits the northern regions of Asia and America. The cat is European; and altogether eight or ten species of tamed quadrupeds have sprung from native animals.

There are still about 180 wild land-animals in Europe: 45 of these are also found in western Asia, and nine in northern Africa. The most remarkable are the reindeer, elk, red and fallow deer, the roe-buck, glutton, lynx, polecat, several wild-cats, the common and black squirrels, the fox, wild boar, wolf, the black and the brown bear, eight species of weasels, and seven of mice. The otter is common; but the beaver is now found only on the Rhine, the Rhone, the Danube, and some other large rivers; rabbits and hares are numerous; the hedgehog is everywhere; the porcupine in southern Europe only; the chamois and ibex in the Alps and Pyrenees. Many species of these animals are widely distributed over Europe, generally with variations in size and colour. The chamois of the Alps and Pyrenees, though the same in species, is slightly varied in appearance; and the fox of the most northern parts

of Europe is larger than that in Italy, with a richer fur, and somewhat different colour.

Some animals never descend below a certain height, as the ibex and chamois, which live on higher ground than any of their order, being usually found between the region of trees and the line of perpetual snow, which is about 8900 feet on the southern, and 8200 on the northern declivities of the Alps. The common stag does not go above 7000 feet, and the fallow-deer not more than 6000, above the level of the sea: these two, however, descend to the plains, the former never do. The bear, lynx, and the stoat ascend nearly to the limit of perpetual snow.

Some European animals are much circumscribed in their locality. The ichneumon is peculiar to Egypt; the mouflon is confined to Corsica and Sardinia; there are a weasel and bat which inhabit Sardinia only; and Sicily has several peculiar species of bats and mice. There is only one species of monkey in Europe, which lives on the rock of Gibraltar, and is supposed to have been brought from Africa. All the indigenous British quadrupeds now existing, together with the hyæna, tiger, bear, and wolf, whose bones have been found in caverns, are also found in the same state in Germany. Ireland was separated by the Irish Channel before all the animals had migrated across England; so that our squirrel, mole, polecat, dormouse, and many smaller quadrupeds, never reached the sister island. Mr. Owen has shown that the British horse, ass, hog, the smaller wild ox, the goat, roe,

beaver, and many small rodents, are the same species with those which had co-existed with the mammoth, the great northern hippopotamus, and two kinds of rhinoceros long extinct. So that a part only of the modern tertiary fauna has perished, from whence he infers that the cause of their destruction was not a violent universal catastrophe from which none could escape. The Bos longifrons was co-existent with man.

ASIATIC QUADRUPEDS.

Asia has a greater number and a greater variety of wild animals than any country, except America, and also a larger proportion of those that are domesticated. Though civilized from the earliest ages, the destruction of the animal creation has not been so great as in Europe, owing to the inaccessible height of the mountains, the extent of the plains and deserts, and, not least, to the impenetrable forests and jungles, which afford them a safe retreat: 288 mammalia are Asiatic, of which 186 are common to it and other countries; these, however, chiefly belong to the temperate zone.

Asia Minor is a district of transition from the fauna of Europe to that of Asia. There the chamois, the bouquetin, the brown bear, the wolf, fox, hare, and others, are mingled with the hyæna, the Angora goat, which bears a valuable fleece, the Argali or wild sheep, the white squirrel; and even the Bengal royal tiger is sometimes seen on Mount Ararat, and

is not uncommon in Azerbijan and the mountains in Persia.

Arabia is inhabited by the hyæna, panther, jackal, wolf, and musk-deer. Antelopes and monkeys are found in Yemen and Aden. Most of these are also indigenous in Persia. The wild ass, or Onagra, a handsome spirited animal of great speed, and so shy that it is scarcely possible to come near it, wanders in herds over the plains and table-lands of central Asia. It is also found in the Indian desert, and especially in the Run of Cutch—" the wilderness and the barren lands are his dwelling"—and in the most elevated regions of Tartary and Tibet, on the shores of the sacred lakes of Manasarowar and Rakastal, at a height of more than 15,250 feet above the sea.[1]

The table-lands and mountains which divide eastern Asia almost into polar and tropical zones, produce as great a distinction in the character of its indigenous fauna. The severity of the climate in Siberia renders the skins of its numerous fur-bearing animals more valuable. These are reindeer, elks, wolves, the large white bear, that lives among the ice on the Arctic shores, several other bears, the lynx, various kinds of martens and cats, the com-

[1] It is by no means certain that the wild Ass of the three countries mentioned in the text belongs to the same species. The Kiang of Tibet appears to be the same as the Dziggetai (Equus Hemonus) of Pallas, which is met with throughout central Asia; but the species found in the Run of Cutch is of a different colour and form: whilst the one neighs like a horse, the other brays like an ass; in one the striped colour of the zebra family exists in the young, and not in the second.

mon, the blue, and the black fox, the ermine, and sable. The fur of these last is much esteemed, and is only equalled by that of the sea-otter, which inhabits the shores on both sides of the northern Pacific.

With the exception of the Jerboa, which burrows in sandy deserts, on the table-land and elsewhere, all the Asiatic species of gnawers are confined to Siberia. The most remarkable of these is the flying squirrel. The Altaï Mountains teem with wild animals, besides many of those mentioned. There are large stags, bears, some peculiar weasels, the argali, and the wild sheep. The wild goat of the Alps is found in the Sayansk part of the chain; the glutton and musk-deer in the Baikal; and in Da-Ouria the red-deer and the Antelope Saiga. The Bengal tiger and the Felis Irbis, a species of panther, wander from the Celestial Mountains to the Altaï chain and southern Siberia: the Tiger is met with even on the banks of the Obi, and also in China, though in the northern regions it differs considerably from the same species in Bengal; thus it can bear a mean annual temperature of from 81° of Fahrenheit to the freezing point. The Tapir, and many of the animals of the Indian Archipelago, are found in the southern provinces of the Chinese empire; but its fauna is little known. It is, however, probable that in the northern parts it resembles that of the Altaï mountains and Siberia. The animals of Japan have a strong analogy to those of Europe: many are identical, or slightly varied, as the badger, otter,

mole, common fox, marten, and squirrel. On the other hand, a large species of bear in the island of Jezo resembles the grizzly bear in the Rocky Mountains of North America. A chamois in other parts of Japan is similar to the Antelope montana of the same mountains: and other animals native in Japan are the same with those in Sumatra; so that its fauna is connected with that of very distant regions.

A few animals are peculiar to the high cold plains of the table-land of eastern Asia: the dziggetai, a very fleet animal, resembling both the horse and the ass, is peculiar to these Tartarian steppes; it is probably the same species as the Kiang of Tibet, which inhabits at very great heights, and has been seen on the banks of the sacred lake of Manasarowar, at an elevation of 15,250 feet, by Lieutenant Strachey: two species of antelopes inhabit the plains of Tibet, congregating in immense herds, with sentinels so vigilant that it is scarcely possible to approach them.

The Dzeran, or yellow goat, which is both swift and shy, and the handsome Tartar ox, are native in these wilds; also the shawl-wool goat and the manul, from which the Angora cat, so much admired in Persia and Europe, is descended. Most of the animals that live at such heights cannot exist in less elevated and warmer regions, exhibiting a striking instance of the limited distribution of species. Goats and sheep best endure the thin air and great cold of high lands: the Cashmere goat and Argoli sheep browse on the plains of Tibet at elevations of from 10,000 to

13,000 feet; the rass, a sheep with straight spiral horns, lives on the table-lands of Pamer, which are 15,000 feet above the sea; and also the kutch-gar, a species of sheep which is about the height of a year-old colt, with fine-curling horns: they congregate in flocks of many hundreds, and are hunted by the Kirghis.

The ruminating animals of Asia are more numerous and excellent than those of any other part of the world; 64 species are native, and 46 of these exist there only. There are several species of wild oxen; one in the Birmese empire, and on the mountains of north-eastern India, with spiral twisted horns. The buffalo is native in China, India, Borneo, and the Sunda Islands; it is a large animal, formidable in a wild state, but domesticated universally in the East. It was introduced into Italy in the sixth century, and large herds now graze in the low marshy plains near the sea.

Various kinds of oxen have been domesticated in India time immemorial: the handsome Indian ox, with a hump on the shoulder, has been venerated by the Brahmins for ages; the beautiful white silky tail of the domesticated ox of Tartary, used in the East to drive away flies, was adopted as the Turkish standard; and the common Indian ox differs from all others in the great speed of its course. Some other species of cattle have been tamed, and some are still wild in India, Java, and other Asiatic islands. The Cashmere goat, which bears the shawl-wool, is the most valuable of the endless varieties of goats and sheep of Asia; it is kept in large herds in the great valleys

on the northern and southern declivities of the Himalaya, and in the upper regions of Bhotan, where the cold climate is congenial to it.

The Bactrian camel, with two humps, is strong, rough, and hairy, and is said to occur in a wild state in the desert of Shamo: it is the camel of central Asia, north of the Himalaya and Taurus, also of the Crimea and the countries round the Caucasus. The common or Arabian camel with one hump is a native of Asia, though only known now in a domesticated state; it has been introduced into Africa, Italy, the Canary islands, and even into the elevated regions of the Peru-Bolivian Andes. The best come from the province of Nejed in Arabia, which, on that account, is called the "mother of camels." The camel of Oman is remarkable for beauty and swiftness.

Ten species of antelopes and twenty of deer are peculiar to Asia: two species of antelopes have already been mentioned as peculiar to the table-lands, the others are distributed in the Asiatic archipelago. The genuine musk-deer (Moschus moschiferus) inhabits the mountainous countries of central and south-eastern Asia, between China and Tartary, the regions round Lake Baikal, the Altaï mountains, Nepaul, Bhotan, Tibet, and the adjacent countries of China and Tonquin.

Asia possesses about ten native species of Pachydermata, including the elephant, horse, ass, which have been domesticated from the time of the earliest scriptural records. The horse is supposed to have existed wild in the plains of central Asia, as the dromedary

in Arabia; though now they are only known as domestic animals. The Arabian and Persian horses have acknowledged excellence and beauty, and from these our best European horses are descended; the African horse, which was introduced into Spain by the Moors, is probably of the same race.

The elephant has long been a domestic animal in Asia, though it still roams wild in formidable herds through the forests and jungles at the foot of the Himalaya, in other parts of India, the Indo-Chinese peninsula, and the islands of Sumatra and Ceylon; the hunting elephant is esteemed the most noble. A one-horned rhinoceros is a native of continental Asia.

There are 60 genera of Asiatic carnivorous animals, of which the royal tiger is the handsomest and the most formidable: its favourite habitation is in the jungles of Hindostan, though it wanders nearly to the limit of perpetual snow in the Himalaya, to the Persian and Armenian mountains, to Siberia and China. Leopards and panthers are common, and there is a maneless lion in Guzerat: the Chitta, used in hunting, is the only one of the panthers capable of being tamed. The hyæna is found everywhere, excepting the Birman empire, in which there are neither wolves, hyænas, foxes, nor jackals. There are four species of bears in India; that of Nepaul has valuable fur: the wild boar, hog, and dogs of endless variety, abound.

The Edentata have only two representatives in India, both manis or pangolins; which differ from all others except the African, in being covered with

imbricated scales. Of these the short-tailed pangolin, or scaly anteater, is found throughout the Deccan, Bengal, Nepaul, the southern provinces of China, and Formosa.

The Indian Archipelago and the Indo-Chinese peninsula form a zoological province of a very peculiar nature, being allied to the faunas of India, Australia, and South America, yet having animals exclusively its own. The royal tiger is in great abundance in the Malay peninsula, and also the black variety of the panther, leopard, wild cats, multitudes of elephants, the rhinoceros of all three species, the Malayan tapir, many deer, the Babiroussa hog, and another species of that genus. Some groups of the islands have several animals in common, either identical or with slight variations, that are altogether wanting in other islands, which, in their turn, have creatures of their own. Many species are common to the archipelago and the neighbouring parts of the continent, or even to China, Bengal, Hindostan, and Ceylon. Flying quadrupeds are a distinguishing feature of this archipelago, though some do not absolutely fly, but, by an extension of the skin of their sides to their legs, which serves as a parachute, they take long leaps. Nocturnal flying squirrels, of several species, are common to the Malayan peninsula and the Sunda Islands, especially Java; and three species of flying Lemurs inhabit Sunda, Malacca, and the Pelew Islands. Besides these, there are the frugivorous bats, which really fly, differing from bats in other countries by living exclusively upon vegetable food. The

edible roussette, or kalong, one of the largest known, appears in flocks of hundreds, and even thousands, in Java, Sumatra, and Banda: the Pteropus funereus, another of these large bats, assembles in as great numbers.

A hundred and eighty species of the ape and monkey tribe are entirely Asiatic: monkeys are found only on the coast of India, Cochin-China, and the Sunda Islands; the long-armed apes or gibbons are in the Sunda Islands and the Malayan peninsula. The Simayang, a very large ape of Sumatra and Bencoolen, goes in large troops, following a leader, and makes a howling noise at sunrise and sunset that is heard miles off. Sumatra and Borneo are the peculiar abode of the Orang-outang, which in the Malay language means the "man of woods," which, except perhaps the Chimpanzee of Africa, approaches nearest to man. It has never spread over the islands it inhabits, though there seems to be nothing to prevent it, but it finds all that is necessary within a limited district. The orang-outang and the long-armed apes have extraordinary muscular strength, and swing from tree to tree by their arms.

The Malays have given the name of orang, or man, to the whole tribe, on account of their intelligence as well as their form.

A two-horned rhinoceros is peculiar to Java, of a different species from the African, also the Felis macrocelis, and a very large bear; there are only two species of squirrels in Java, which is remarkable, as the Sunda Islands are rich in them. The royal

tiger of India and the elephant are found only in Sumatra, and the babiroussa lives in Borneo; but these two islands have many quadrupeds in common, as a leopard, the one-horned rhinoceros, the black antelope, some graceful miniature creatures of the deer kind, the Tapir, also found in Malacca, besides a wild boar, an inhabitant of all the marshy forests from Borneo to New Guinea. In the larger islands deer abound, some as large as the elk, probably the Hippelaphus of Aristotle.

The Anoa, a ruminating animal about the size of a sheep, a species of antelope, shy and savage, goes in herds in the mountains of Celebes, where many forms of animals strangers to the Sunda Islands begin to appear, as some sorts of phalangers, or pouched quadrupeds. These new forms become more numerous in the Moluccas, which are inhabited by flying phalangers and other pouched animals, with scaly tails. The phalangers are nocturnal, and live on trees. In New Guinea there are kangaroos, the spotted phalanger, the pelandoe, the New Guinea hog, and the Papua dog, said to be the origin of all the native dogs in Australia and Oceanica, wild or tame.

The fauna of the Philippine Islands is analogous to that in the Sunda Islands. They have several quadrupeds in common with India and Ceylon, but there are others which probably are not found in these localities.

AFRICAN QUADRUPEDS.

The opposite extremes of aridity and moisture in the African continent have had great influence in the nature and distribution of its animals; and since by far the greater part consists of plains utterly barren or covered by temporary verdure, and watered by inconstant streams that flow only a few months in the year, fleet animals, fitted to live on arid plains, are far more abundant than those that require rich vegetation and much water. The latter are chiefly confined to the intertropical coasts, and especially to the large jungles and deep forests at the northern declivity of the table-land, where several genera and many species exist that are not found elsewhere. Africa has a fauna in many respects insulated from that of every other part of the globe; for although about 100 of its quadrupeds are common to other countries, there are 250 species its own. Several of these animals, especially the larger kinds, are distributed over the whole table-land from the Cape of Good Hope to the highlands of Abyssinia and Senegambia without the smallest variety, and many are slightly modified in colour and size. Ruminating animals are very numerous, though few have been domesticated: of these the ox of Abyssinia and Bornou is remarkable from the extraordinary size of its horns, which are sometimes 2 feet in circumference at the root; and the Galla ox of Abyssinia has horns 4 feet long. There are many African varieties of buffalo; that at the Cape of Good Hope is a

large, fierce animal, wandering in herds in every part of the country, even to Abyssinia: the flesh of the whole race is tainted with the odour of musk. The African sheep and goats, of which there are many varieties, differ from those of other countries; the wool of all is coarse, except that of the Merino sheep, said to have been introduced into Spain by the Moors from Morocco.

No country has produced a ruminating animal similar, or even analogous, to the Giraffe, or Camelopard, which ranges widely over south Africa from the northern banks of the Gareep, or Orange river, to the Great Desert; it is also found in Dongola and in Abyssinia. It is a gentle, timid animal, which has been seen in troops of 100. The earliest record we have of it is in the sculptured monuments of the ancient Egyptians, and it is well known that it was brought to Rome to grace the triumph of a victorious emperor.

Africa may truly be said to be the land of the genus Antelope, which is found in every part of it, where it represents the deer of Europe, Asia, and America. Different species have their peculiar localities, while others are widely dispersed, sometimes with and sometimes without any sensible variety of size or colour. The greater number are inhabitants of the plains, while a few penetrate into the forests. Sixty species have been described, of which at least 26 are found north of the Cape of Good Hope and in the adjacent countries. They are of every size, from the pigmy antelope not larger

than a hare, to the Caama, which is as large as an ox. Timidity is the universal character of the race. Most species are gregarious; and the number in a herd is far too great even to guess at. Like all animals that feed in groups, they have sentinels; and they are the easy prey of so many carnivorous animals, that their safety requires the precaution. At the head of their enemies is the lion, who lurks among the tall reeds at the fountain, to seize them when they come to drink. They are graceful in their motions, especially the spring-buck, which goes in a compact troop; and in their march there is constantly one which gathers its slender limbs together and bounds into the air.

Africa has only two species of deer, both belonging to the Atlas: one is the common fallow-deer of Europe.

The 38 species of rodentia, or gnawing quadrupeds, of this continent, live on the plains; and many of them are leaping animals, as the Jerboa capensis. Squirrels are comparatively rare.

There are some species of the horse peculiar to south Africa; of these the gaily-striped Zebra and the more sober-coloured Quagga wander in troops over the plains, often in company with ostriches. An alliance between creatures differing in nature and habits is not easily accounted for. The two-horned rhinoceros of Africa is different from that of Asia: there are certainly three, and probably five, species of these huge animals peculiar to the table-land. Dr. Smith saw 150 in one day near the 24th

parallel of south latitude. The hippopotamus is exclusively African: multitudes inhabit the lakes and rivers in the intertropical and southern parts of the continent; those that inhabit the Nile and Senegal appear to form different species. An elephant, differing in species from that of Asia, is so numerous, that 200 have been seen in a herd near Lake Tchad. They are not domesticated in Africa, and are hunted by the natives for their tusks. The Phacochœre, or Ethiopian hog, and a species of Hyrax, are among the Pachydermata of this country. The monkey tribe is found in all the hot parts of Africa: peculiar genera are allotted to particular districts. Except a few in Asia, the family of guenons is found in no part of the world but the Cape of Good Hope, the coasts of Loango and Guinea, where they swarm.

The species are numerous, and vary much in size and colours: the cynocephalus, or blue-headed baboon, with a face like that of a dog, is large, ferocious, and dangerous. One species of these baboons inhabits Guinea, others the southern parts of the table-land, and one is met with everywhere from Sennaar to Cafraria. A remarkable long-eared kind is found in Abyssinia; the mandrills, which belong to the same genus, are confined to central Africa. The magot or Barbary ape is in north Africa; and the only macac in this continent inhabits the mountains in the high country of southern Abyssinia, 8000 feet above the level of the sea. The African species of thumbless apes are met with in the tropical countries on the west coast, where the Colobus comosus, or

king of the monkeys, also lives, so called by the natives from its beautiful fur and singular head of hair; another of these is peculiar to the low lands of Gojam, Kulla, and Damot. The Chimpanzee, which so nearly approaches the human form, inhabits the forests of south Africa from Cape Negro to the Gambia. Living in society like all apes and monkeys, which are eminently sociable, it is very intelligent and easily tamed. A new species of African Chimpanzee, equalling in size the Orang-outang, has been recently described by Professor Owen: it is probably the largest of the quadrumana, and by all accounts the most dangerous and ferocious.

Baron Humboldt observes that all apes resembling man have an expression of sadness; that their gaiety diminishes as their intelligence increases.

Africa possesses the cat tribe in great variety and beauty; lions, leopards, and panthers are numerous throughout the continent; servals and viverrine cats are in the torrid districts; and the lion of the Atlas is said to be the most formidable of all. In no country are foxes so abundant. Various species inhabit Nubia, Abyssinia, and the Cape of Good Hope. The corsac is peculiar to the Cape. The long-eared fox, the famel of Kordofan, and some others, are found in Africa only. There are also various species of dogs, the hyæna, and the jackal. The hyænas hunt in packs, attack the lion and panther, and easily destroy them.

Two species of Edentata are African—the long-tailed manis, and the Aard-vark, or earth-hog: the

first is covered with scales, the latter with coarse long hair; they burrow in the ground and feed on ants. Great flocks of a large migratory vampire-bat frequent the Slave-coast. Altogether there are 26 species of African bats.

Multitudes of antelopes of various species, lions, leopards, panthers, hyænas, jackals, and some other carnivora, live in the oases of the great northern deserts; jerboas, and endless species of leaping gnawers, rats, and mice burrow in the ground. The dryness of the climate and soil keeps the coats of the animals clean and glossy; and it has been observed that tawny and grey tints are the prevailing colours in the fauna of the north African deserts, not only in the birds and beasts, but in reptiles and insects. In consequence of the continuous desert extending from North Africa through Arabia to Persia and India, many analogous species of animals exist in those countries: in some instances they are the same, or varieties of the same, species, as the ass, the dziggeti, antelopes, leopards, panthers, jackals, and hyænas.

The fauna on the eastern side of the great island of Madagascar is analogous to that of India; on the western side it resembles that of Africa, though, as far as it is known, it seems to be a distinct centre of animal life. It has no ruminating animals; and the monkey tribe is represented by the Lemures and the Galagos, which are characteristic of this fauna. A frugivorous bat, the size of a common fowl, forms an article of food.

AMERICAN QUADRUPEDS.

No species of animal has yet been extirpated in America, which is the richest zoological province, possessing 537 species of mammalia, of which 480 are its own; yet no country has contributed so little to the stock of domestic animals. With the exception of the Llama and Alpaca, and the turkey, and perhaps some sheep and dogs, America has furnished no animal or bird serviceable to man, while it has received from Europe all its domestic animals and its civilized inhabitants.

Arctic America possesses most of the valuable fur-bearing animals that are in Siberia; and they were very plentiful till the unsparing destruction of them has driven those yet remaining to the high latitudes, where the hunters that follow them are exposed to great hardships. Nearly 6,000,000 of skins were brought to England in one year, most of which were taken in the forest regions; the barren grounds are inhabited by the Arctic fox, the polar hare, by the brown and the white bear, a formidable animal which often lives on the ice itself. The reindeer lives on the lichens and mosses of these barren grounds, and wanders to the shores of the Polar Ocean: its southern limit in Europe is the Baltic Sea, in America it is the latitude of Quebec. Some of the fur-bearing quadrupeds of these deserts never pass the 65th degree of N. lat.; the greater number live in the northern forests, as the black bear, racoon, badger, the ermine, nd four or five other members of the weasel tribe,

the red fox, the polar and brown lynxes, the beaver, the musquash or musk-rat, of which half a million are killed annually, and the moose-deer, whose northern range ends where the aspen and willows cease to grow. The grizzly bear, the largest and most ferocious of its kind, inhabits the range of the Rocky Mountains to Mexico, as well as the western savannahs. The prairie-wolf, the grey fox, the Virginian hare, live in the prairies; the Wapiti, a large stag, inhabits those on both sides of the Rocky Mountains; and the Prongbuck, an antelope fleeter than a horse, roams throughout the western part of the continent, and migrates to California and Mexico in winter. The musk-ox and shaggy bison are peculiar to North America. The musk-ox travels to Parry's Islands in the Arctic regions, yet it never has been seen in Greenland or on the north-western side of the continent. The shaggy bison goes south to the Arkansas, roams in herds of thousands over the prairies of the Mississippi and on both sides of the Rocky Mountains. It never wanders farther north than the 30th parallel, the southern limit of the musk-ox. A marmot known as the prairie-dog is universal.

There are at least eight varieties of American dogs, several of which are natives of the far north. The lagopus, or isatis, native in Spitzbergen and Greenland, is found in all the Arctic regions of America and Asia and in some of the Kurile Islands. Dogs are employed to draw sledges in Newfoundland and Canada; and the Esquimaux travel drawn by dogs as well as by reindeer. The dogs are strong and

docile. The Esquimaux dogs were mute till they learned to bark from dogs in our discovery ships.

There are 13 species of the ruminating genus in North America, including the bison, the musk-ox of the Arctic regions, the big-horned sheep, and the goat of the Rocky Mountains. The horse, now roaming wild in innumerable herds over the plains of South America, was unknown there till the Spanish conquest. The quadrupeds of the temperate zone are distributed in distinct groups: those of the state of New York, consisting of about 40 species, are different from those of the Arctic regions, and also from those of South Carolina and Georgia; while in Texas another assemblage of species prevails. The Racoon, the Coatimondi, and the Kinkajou are all natives of the southern States.

There are 118 species of rodentia or gnawing animals in North America, rats, mice, squirrels, beavers, &c., many of which, especially in the north, appear to be identical with those in the high latitudes of Europe and Asia. The genera of very different latitudes are often representative but never identical. Squirrels abound in North America; the grey squirrel is found in thousands.

There are 21 species of Opossum in this continent, a family of the pouched animals which are so peculiarly characteristic of Australia. Of these the Virginian opossum inhabits the whole extent of the American continent between the great Canadian lakes and Paraguay, and also the West Indian islands, where it is called the manitu; and two other

animals of that order live in Mexico. There is a porcupine in the United States and Canadian forests which climbs trees. The bats are different from those in Europe, and, excepting two, are very local. In California there are ounces, polecats, the Berenda (an animal peculiar to that country), and a deer of remarkable size and speed.

The high land of Mexico forms a very decided line of division between the fauna of North and that of South America; yet some North American animals are seen beyond it, particularly two of the bears, and one of the otters, which inhabits the continent from the icy ocean to beyond Brazil. On the other hand, the Puma, Jaguar, Opossum, Kinkajou, and Peccari have crossed the barrier from South America to California and the United States.

In the varied and extensive regions of South America there are several centres of a peculiar fauna according as the country is mountainous or level, covered with forest or grass, fertile or desert, but the mammalia are inferior in size to those of the old world. The largest, most powerful, and perfect animals of this class are confined to the old continent. The South American quadrupeds are on a smaller scale, more feeble and more gentle; many of them, as the toothless group and the sloths, are of anomalous and less perfect structure than the rest of the animal creation, but the fauna of South America is so local and so peculiar, that the species of five of the terrestrial orders, which are indigenous there, are found nowhere else.

The monkey tribe are in myriads in the forests of tropical America and Brazil, but they never go north of the Isthmus of Darien, nor farther south than the Rio de la Plata. They differ widely from those in the old world, bearing less resemblance to the human race, but they are more gentle and lively, and, notwithstanding their agility, are often a prey to the vulture and puma.

There are two great American families of four-handed animals—the sapajous with prehensile tails, by which they suspend themselves, and swing from bough to bough. Some of these inhabitants of the woods are very noisy, especially the Argualis, a large ape whose bawling is heard a mile off. The howlers are generally very large, and have a wider range than any of the genus; one species, the Mycetus rufimanus or beelzebub, ascends the Andes to the height of 11,000 feet. The cebus or weepers, which are frequently brought to Europe, belong also to this family; the genus has a greater number of species than any other in the New World, but a very narrow location; they are most abundant in Guiana.

The saquis or bushy-tailed monkeys form the other great American family. The fox-monkey sleeps during the day; it frequents the deepest forests from the Orinoco to Paraguay. Squirrel-monkeys inhabit the banks of the Orinoco, and the night-monkeys, with very large eyes, live in Guiana and Brazil. The marmosets are pretty little animals, easily tamed, especially the Midas leonina, not more than

7 or 8 inches long. Some American monkeys have no thumb, others have a versatile thumb on both their hands and feet. In the New World the monkey tribe inhabit the continent from Honduras to beyond Brazil, in thousands, yet each kind has its own peculiar location.

The forests are also inhabited by opossums, a family of the marsupial tribe, or animals with pouches, in which they carry their young; they are analogous to those which form the distinguishing feature of the Australian fauna, but of distinct genera and species. Few of these animals are larger than a rat, and they mostly live on trees, except one kind which is aquatic, found near the small streams from Honduras to Brazil. A species in Surinam carries its young upon its back; the elegant opossum is very numerous on the west side of the Andes, and there only. All the opossums and the yassacks of this country have thumbs on their hind feet, opposite to the toes, so that they can grasp; they are, moreover, distinguished from the Australian family by a long prehensile tail, and by greater agility. The numerous tribe of sapajou monkeys, the ant-eaters, the kinkajou, and a species of porcupine, have also grasping tails, a property of many South American animals.

Five genera and 20 species of the Edentata are characteristic of this continent, and exclusively confined to South America: they are the sloths of two kinds, the ai and unau; the Armadilloes, Chlamyphores, and Anteaters. The animals of these five genera have very different habits: the sloths, as

their name implies, are the most inactive of animals; they inhabit the forests from the southern limit of Mexico to Rio de Janeiro, and to the height of 3000 feet on the Andes in the region of palms and scitamineæ. Of these the common sloth or Ai ranges from Honduras to Brazil; while the Unau, the larger of the two, is confined to Guiana. The Armadillo, in its coat of mail, is in perpetual motion, and can outrun a man in speed. They live on all the plains and table-lands of South America even to Paraguay. The one-banded armadillo rolls itself up like a ball; the nine-banded species is eaten by the natives; the giant armadillo, 3 feet long, inhabits the forests only. Most species of these animals are nocturnal, and burrow in the earth in the Pampas. The chlamyphores are also burrowing animals, peculiar to the province of Cuyo on the eastern slope of the Chilian Andes; they have the faculty of sitting upright. The ant-eater, larger than a Newfoundland dog, with shorter legs, defends itself against the jaguar with its powerful claws; it inhabits the swampy savannahs and damp forests from Columbia to Paraguay, and from the Atlantic to the foot of the Andes; its flesh, like that of some other American animals, has a flavour of musk. The little ant-eater has a prehensile tail, and lives on trees in the tropical forests, feeding on the larvæ of bees, wasps, honey, and ants; another of similar habits lives in Brazil and Guiana. The cat tribe in South America is beautiful and powerful: the Puma, the lion of America, is found both in the mountains and the plains, in great numbers; so dif-

ferent are its habits in different places, that in Chile it is timid and flies from a dog; in Peru it is bold, though it rarely attacks a man. The Jaguar, which inhabits the lower forests, is very abundant, and so ferocious that it has been known to spring upon Indians in a canoe; hunting as it sometimes does in troops, it has been known to destroy the inhabitants of entire Indian villages; it is one of the few South American animals that cross the Isthmus of Darien, being found in California, on the territory of the Mississippi, and has been seen in Canada.

The vampire is a very large bat, much dreaded by the natives, because it enters their huts at night, and, though it seldom attacks human beings, it wounds calves and small animals, which sometimes die from the loss of blood. The other three South American bats are harmless.

The only ruminating animals that existed in South America prior to the Conquest were the four species of the genus Auchenia—the Llama, the Alpaca, the Vicugna, and the Guanaco: the three first are exclusively confined to the colder and more elevated regions of the Peruvian Andes; the last has a wider geographical range, extending to the plains of Patagonia, and even to the southernmost extremity of the continent. The Llama inhabits the high valleys of the Peru-Bolivian Andes, its favourite region being in the valley of the lake of Titicaca: it was the only beast of burthen possessed by the aborigines; hence we find it wherever the Incas carried their conquests and civilization, from the equator to beyond the

southern tropic. It is still extensively employed by the Indian as a beast of burthen, and its wool, though coarse, is used by the aborigines: like all domestic animals, it varies in colour; its flesh is nauseous, black, and ill tasted.

The Alpaca, or paco, a gentle and handsome animal, although more closely allied to the llama than any of its congeners, is a distinct species: it inhabits at still more elevated places than the llama, its favourite haunts being on the streams descending from the snowy peaks: it is only found in a domestic state; it is reared for its wool, which is extremely fine, silky, and long, and which now bears a high price, from its introduction into some of our finest woollen tissues. The vicugna is only found in the wild state, in the plains on the Andes, as high as 1500 feet: its wool is much prized for its fineness. The animal has a shrill whistle; it is easily domesticated. The Guanaco, by some naturalists considered erroneously as the parent stock of the llama and alpaca, is also only found in the wild state: it is seen as far north as lat. 12° S., is very abundant and in large flocks on the Bolivian and Chilian Andes, and has been seen as far as the southern extremity of the American continent. All these animals feed on a species of coarse wiry grass called ichu.[1]

[1] The attention of the scientific world in France has been recently directed to the advantages that might arise from the naturalization of the Llama tribe in Europe, and especially of its two most useful species, the Llama and the Alpaca. M. J. Geoffroy St. Hilaire, a zoologist of some note, but rather car-

Several species of deer are found in the tropical regions of South America, and a remarkable species,

ried away by theoretical views in a branch of science where observation, and observation alone, ought to be our guide, and ignorant perhaps of what had been done in England on the same subject, where the experiment had long since been tried, and with very inadequate success, has presented lately some papers to the Academy of Sciences on this subject. We cannot imagine, even if the naturalization of the Llama on a large scale was possible, what benefit could arise from it to our agriculturists. The wool of the llama is coarse, and so infinitely inferior to the commonest qualities of sheep's wool, that in its native country it is seldom used for any other purpose than the manufacture of ropes, of a rough carpeting and packing-cloth, and for the coarsest apparel of the poor Indian. As to its use as a beast of burden, whilst the llama eats as much as the ass, it does not carry more than one half what he can, and can scarcely travel one half of the same daily distance; besides, the female llama is useless in this respect. The flesh of the llama, as above stated, is greatly below that of all our domestic animals, even of the Italian buffalo.

As to the Alpaca, it is very doubtful if, living as it does in an extremely dry, elevated, equable, and clear atmosphere, it would ever become accustomed to the damp and variable climate of our northern latitudes, or to that of the great European chains of mountains, the Alps and the Pyrenees, and if it did, that its wool would not be greatly deteriorated. As to the vicuña, it is purely a wild species, and has hitherto resisted all the efforts of the aborigines, the most patient and docile of the human race, to render it prolific in its own climate and in domesticity.

It appears, therefore, that the domestication of the several species of Auchenia in Europe would be a costly and useless experiment, on the large scale on which it is proposed to try it; indeed, this will appear evident when it is known that in the Peru-Bolivian Andes the llama and alpaca are daily disappearing to make room for the more useful and profitable

with fragile hair like that of the roebuck, the cervus (Andium), as high as 11,000 feet in the Andes.

The rodentia, or gnawers, of South America are very numerous; there are 92 in Brazil alone: there are only 8 species of squirrels and 64 species of rats and mice, some of which are very peculiar.

breed of the common European sheep, whilst, as a beast of burden, the ass is everywhere taking its place.

Connected with this subject, a very singular fact, and, if well established, a very curious one, has been announced by M. Geoffroy St. Hilaire, on the authority of one of our countrymen, Dr. Weddel, recently returned from South America, that a cross-breed between the Alpaca and the Vicuña had been obtained, and that the mules from this cross-breed were capable of reproducing this newly created species, the wool of which is represented to be of a valuable quality. Now, if there exists in zoological science a fact clearly established, it is this: that within historical periods no new species of vertebrate animal has been created—in fact, the great law of the immutability of species. The remains of the several wild animals which have been buried for more than 30 centuries in the catacombs of Egypt, and in the ruins of Nineveh, are perfectly identical with those now existing in the most minute details of their anatomical structure. We have examined, in the case referred to, the evidence adduced by M. Geoffroy St. Hilaire in support of his favourite doctrine, and we do not by any means consider it sufficient to shake the conclusions arrived at by all the great zoologists of past and present times—by the Cuviers, the Humboldts, and the Owens of our own period —on the impossibility of the production of a new species of animals, or the immutability of species in the animal creation. Contradictions to this law we know have been brought forward by writers of the theoretical school of naturalists, to support favourite theories of their authors; but we believe such dangerous doctrines are founded on the vagaries of a school which have ever placed in natural history observation in the back, and the dreams of imagination in the foreground.

The agoutis represent our hares in the plains of Patagonia, in Paraguay, &c., and extend as far as Guiana. The family of the cavias, or guinea-pigs, are found in Brazil, and some species in the great table-lands of the Peru-Bolivian Andes; the Echymys, or spiny rat, is an inhabitant of the shores of the Rio de la Plata and Paraguay; the Vizcacha of the Pampas, a burrowing animal, inhabits the great plain of Buenos Ayres; an animal bearing the same name is frequent in the rocky districts of the Andes, as high as 15,000 feet above the sea; and the beautiful Chinchilla, nearly allied to the latter, whose fur is so highly esteemed, inhabits the same regions at the same great elevations in the Andes of Peru, Bolivia, and Chile: the best fur of the chinchilla is collected in the Bolivian province of Potosi, and in the Chilian province of Copiapo. The largest of all the rodentia, the Cabiai (Myopotamus,) inhabits the banks of the great rivers of tropical America, where its habits resemble, according to some travellers, those of the hippopotamus. The Paca, the next in size, is less aquatic in its habits, and lives in the dense forests of Brazil and Paraguay.

It is very remarkable that in a country which has the most luxuriant vegetation there should not be one species of hollow-horned ruminants, as the ox, sheep, goat, or antelope; and it is still more extraordinary that the existing animals of South America, which are so nearly allied to the extinct inhabitants of the same soil, should be so inferior in size not only to them, but even to the living quadrupeds of

South Africa, which is comparatively a desert. The quantity of vegetation in Britain at any one time exceeds the quantity on an equal area in the interior of Africa ten-fold, yet Mr. Darwin has computed that the weight of 10 of the largest south African quadrupeds is 24 times greater than that of the same number of quadrupeds of South America; for in South America there is no animal the size of a cow, so that there is no relation between the bulk of the species and the vegetation of the countries they inhabit.

The largest animals indigenous in the West Indian islands are the Agouti, the Racoon, the Houtias, a native of the forests of Cuba; the Didelphous carnivora and the Kinkajou are common also to the continent: the kinkajou is a solitary instance of a carnivorous animal with a prehensile tail.

AUSTRALIAN QUADRUPEDS.

Australia is not farther separated from the rest of the world by geographical position than by its productions. Its animals are creatures by themselves, of an entirely unusual type; few in species, and still fewer individually, if the vast extent of country be taken into consideration; and there has not been one large animal discovered. There are only 53 species of land quadrupeds in New Holland, and there is not a single example of the ruminating or pachydermatous animals, so useful to man, among them; there are no native horses, oxen, or sheep, yet all these thrive and multiply on the grassy steppes of the

country, which seem to be so well suited to them. There are none of the monkey tribe; indeed they could not exist in a country where there is no fruit.

Of the species of indigenous quadrupeds, 40 are found nowhere else, and 138 are marsupial or pouched animals, distinguished from all others by their young being as it were prematurely born and nourished in the pouch till they are mature.[1] Though all the members of this numerous family agree in this circumstance, they are dissimilar in appearance, internal structure, in their teeth and feet, consequently in their habits; two genera live on vegetable food, one set are gnawers and another toothless. The Kangaroo and the kangaroo-rat walk on their hind legs, and go by bounds, aided by their strong tail; the rat holds its food in its hands like the squirrel; the opossum walks on all fours; the phalangers live on trees, and swing by their bushy

[1] There are 8 families, 14 genera, and 123 species of marsupial animals, amounting to about one-twelfth of all the mammalia. The opossum is American; the seven other families are inhabitants of Australia and the Indian Archipelago.

Of the Didelphidæ or opossum family than are 21 species, all inhabitants of America; the Virginian opossum is about the size of a cat, the other species are not larger than rats or mice. A pretty kind in Surinam, the D. dorsigera, is so named because it carries its young on its back, which hold on by their prehensile tails twisted round that of the mother: another species is aquatic, and in its habits resembles the otter.

The Dasyuridæ and Phalangers are nocturnal: the Dasyuridæ and wombats burrow.

tail, some burrow in the sand; the flying opossum or Phalanger, peculiarly an Australian animal, lives on the leaves of the gum-tree; by expanding the skin of its sides it supports itself in the air in its leaps from bough to bough. Several of the genera come out at night only, a characteristic of many Australian animals.

The pouched tribe vary in size from that of a large dog to a mouse; the kangaroos, which are the largest, are easily domesticated, and are used for food by the natives. Some go in large herds in the mountains, others live in the plains; however, they have become scarce near the British colonies, and, with all other native animals, are likely to be extirpated. In Van Diemen's Land they are less persecuted; several species exist there. The kangaroos, of which there are 40 species, are more widely dispersed than any of the marsupial animals of the old world. They exist not only in New Holland and Van Diemen's Land, but also in New Guinea and Java. Some are limited within narrow bounds: the banded kangaroo, the handsomest of his tribe, is found only in the islands of Shark's Bay, on the west coast of Australia. The Wombat is peculiar to Australia, the islands in Bass's Strait, and Van Diemen's Land; to which the two largest carnivorous marsupials peculiarly belong, called by the natives the tiger hyæna, and the native devil; both are nocturnal, predatory, and ferocious. A wild dog in the woods, whose habits are ferocious, is, with the tiger hyæna, the largest carnivorous animal in Australia.

The gnawing animals are aquatic and very peculiar, but the edentata of New Holland are quite anomalous; of these there are two genera, the Ornithorhynchus, or duck-billed mole, and the Echidna: they are the link that connects the edentata with the pouched tribe, and mammal with oviparous animals. The ornithorhynchus is about 14 inches long, and covered with thick brown fur; its head is similar to that of a quadruped, ending in a bill like that of a duck: it has short furry legs with half-webbed feet, and the hind feet are armed with sharp claws. It inhabits burrows on the banks of rivers, which have two entrances, one above, the other below the level of the water, which it seldom leaves, feeding on insects and seeds in the mud.

The echidna is similar in its general structure to the ornithorhynchus, but entirely different in external appearance, being covered with quills like the porcupine; it is also a burrowing animal, sleeps during winter, and lives on ants in summer.

A singular analogy exists between Australia and South America in this respect, that the living animals of the two countries are stamped with the type of their ancient geological inhabitants, while in England and elsewhere the difference between the existing and extinct generations of beings is most decided. Australia and South America seem still to retain some of those conditions that were peculiar to the most ancient eras. Thus each tribe of the innumerable families that inhabit the earth, the air, and the waters, has a limited sphere. How wonder-

ful the quantity of life that now is, and the myriads of beings that have appeared and vanished![1] Dust has returned to dust through a long succession of ages, and has been continually remoulded into new forms of existence—not an atom has been annihilated; the fate of the vital spark that has animated it, with a vividness sometimes approaching to reason, is one of the deep mysteries of Providence.

[1] Sir Charles Lyell estimates the number of existing species of animals and vegetables, independent of the infusoria, to be between one and two millions, which must surely be under the mark, considering the enormous quantity of animal life in the ocean, to the amount of which we have not even an approximation. If the microscopic and infusorial existence be taken into the account, the surface of the globe may be viewed as one mass of animal life—perpetually dying—perpetually renewed. A drop of stagnant water is a world within itself, an epitome of the earth and its successive geological races. A variety of microscopic creatures appear, and die; in a few days a new set succeeds; these vanish and give place to a third set, of different kinds from the preceding; and the débris of all remain at the bottom of the glass. The extinction of these creatures takes place without any apparent cause, unless a greater degree of putrescence of the water be to them what the mighty geological catastrophes were to beings of higher organization—the introduction of the new is not more mysterious in one case than in the other.

CHAPTER XXXIII.

The Distribution, Condition, and future Prospects of the Human Race.

MORE than 800,000,000 of human beings are scattered over the face of the earth, of all nations and kindreds and tongues, and in all stages of civilization, from a high state of moral and intellectual culture, to savages but little above the animals that contend with them for the dominion of the deserts and forests through which they roam. This vast multitude is divided into nations and tribes, differing in external appearance, character, language, and religion. The manner in which they are distributed, the affinities of structure and language by which they are connected, and the effect that climate, food, and customs may have had in modifying their external forms, or their moral and mental powers, are subjects of much more difficulty than the geographical dispersion of the lower classes of animals, inasmuch as the immortal spirit is the chief agent in all that concerns the human race. The progress of the universal mind in past ages, its present condition, and the future prospects of humanity, rouse the deep sympathies of our nature, for the high but mysterious destiny of the myriads of beings yet to come, who, like ourselves, will be subject for a few brief years to

the joys and sorrows of this transient state, and fellow-heirs of eternal life hereafter.

Notwithstanding the extreme diversity, personal and mental, in mankind, anatomists have found that there are no specific differences—that the hideous Esquimaux, the refined and intellectual Caucasian, the thick-lipped Negro, and the fair blue-eyed Scandinavian, are mere varieties of the same species. The human race forms five great varieties marked by strong distinctive characters. Many nations are included in each; distinguished from one another by different languages, manners, and mental qualities, yet bearing such a resemblance in general physiognomy and appearance as to justify a classification apparently anomalous.

The Caucasian group of nations, which includes the handsomest and most intellectual portion of mankind, inhabit all Europe, except Lapland, Finland, and Hungary; they occupy North Africa, as far as the 20th parallel of north latitude, Arabia, Asia Minor, Persia, the Himalaya to the Brahmapootra, all India between these mountains and the ocean, and the United States of North America. These nations are remarkable for a beautifully-shaped small head, regular features, fine hair, and symmetrical form. The Greeks, Georgians, and Circassians are models of perfection in form, especially the last, which is assumed as the type of this class of mankind; of which it is evident that colour is not a characteristic, since they are of all shades, from the fair and florid, to the clear dark brown and almost black. This

family of nations has always been, and still is, the most civilized portion of the human race. The inhabitants of Hindostan, the Egyptians, Arabians, Greeks, and Romans, were in ancient times what the European nations are now. The cause of this remarkable development of mental power is, no doubt, natural disposition, for the difference in the capabilities of nations seems to be as great as that of individuals. The origin of spontaneous civilization and superiority may generally be traced to the talent of some master-spirit gaining an ascendancy over his countrymen. Natural causes have also combined with mental—mildness of climate, fertility of soil; rivers and inland seas, by affording facility of intercourse, favoured enterprise and commerce; and the double-river systems in Asia brought distant nations together, and softened those hostile antipathies which separate people, multiply languages, and reduce all to barbarism. The genius of this family of nations has led them to profit by these natural advantages; whereas the American Indians are at this day wandering as barbarous hordes in one of the finest countries in the world. An original similarity or even identity of many spoken languages may be adverted to as facilitating communication and mental improvement among the Caucasian variety in very ancient times.

The Mongol-Tartar family forms the second group of nations. They occupy all Asia north of the Persian table-land and of the Himalaya; the whole of Eastern Asia from the Brahmapootra to Behring's Straits, together with the Arctic regions of America

north of Labrador. This family includes the Tourkomans, Mongol and Tartar tribes, the Chinese, Indo-Chinese, Japanese, the Esquimaux, and the Hungarians, now located in the very heart of Europe. These nations are distinguished by broad skulls and high cheek-bones, small black eyes obliquely set, long black hair, and a yellow or sallow olive complexion; some are good-looking, and many are well-made. A portion of this family is capable of high culture, especially the Chinese, the most civilized nation of eastern Asia, although they never have attained the excellence of the Caucasian group, probably from their exclusive social system, which has separated them from the rest of mankind, and kept them stationary for ages; the peculiarity and difficulty of their language have also tended to insulate them. The Kalmuks, who lead a pastoral wandering life on the steppes of central Asia, and the Esquimaux, have wider domains than any other of this set of nations. The Kalmuks are rather a handsome people, and, like all who lead a savage life, have acute senses of seeing and hearing. The inhabitants of Finland and Lapland are nearly allied to the Esquimaux, who are spread over all the high latitudes of both continents—a diminutive race, equally ugly in face and form.

Malayan nations occupy the Indian Archipelago, New Zealand, Chatham Island, the Society group, and several other of the Polynesian islands, together with the Philippines and Formosa. They are very dark, with lank coarse black hair, flat faces, and

obliquely set eyes. Endowed with great activity and ingenuity, they are mild and gentle, and far advanced in the arts of social life, in some places; in others, ferocious and vindictive, daring and predatory; and from their maritime position and skill, they are a migratory race. Several branches of this class of nations had a very early indigenous civilization, with an original literature in peculiar characters of their own.

The Ethiopian nations are widely dispersed; they occupy all Africa south of the Great Desert, half of Madagascar, the continent of Australia, Mindanao, Gilolo, the high lands of Borneo, Sumbawa, Timor, and New Ireland. The distinguishing characters of this group are, a black complexion, black woolly or frizzled hair, thick lips, projecting jaws, high cheek-bones, and large prominent eyes. A great variety, however, exists in this jetty race: some are handsome both in face and figure, especially in Ethiopia; and even in Western Africa, where the Negro tribes live, there are groups in which the distinctive characters are less exaggerated. This great family has not yet attained a high place among nations, though by no means incapable of cultivation; part of Ethiopia appears to have made considerable progress in civilization in very ancient times. But the formidable deserts, so extensive in some parts of the continent, and the unwholesome climate in others, have cut off intercourse with civilized nations; and unfortunately, the infamous traffic in slaves, to the disgrace of Christianity, has made the nations of tropical Africa more barbarous than they were before: while, on the

contrary, the Foulahs and other tribes who were converts to Mahommedanism 400 years ago, have now large commercial towns, cultivated grounds, and schools. The Australians and Papuans, who inhabit the eastern islands mentioned, are the most degraded of this dark race, and indeed of all mankind.

The American race, who occupy the whole of that continent from 62° N. lat. to the Straits of Magellan, are almost all of a reddish brown or copper colour, with long black hair, deep-set black eyes, aquiline nose, and often of handsome slender forms. In North America they live by hunting, are averse to agriculture, slow in acquiring knowledge, but extremely acute, brave, and fond of war, and, though revengeful, are capable of generosity and gratitude. In South America many are half-civilized, but a greater number are still in a state of utter barbarism. In a family so widely scattered great diversity of character prevails, yet throughout the whole there is a similarity of manners and habits which has resisted all the effects of time and climate.

Each of these five groups of nations, spread over vast regions, is accounted one family; and if they are so by physical structure, they are still more so by language, which expresses the universal mind of a people, modified by external circumstances, of which none have a greater influence than the geographical features of the country they inhabit—an influence that is deepest in the early stages of society. The remnants of ancient poetry in the south of Scotland partake of the gentle and pastoral character of the

country; while Celtic verse, and even the spoken language of the Highlander, are full of poetical images of war and stern mountain scenery. This is particularly to be observed in the noble strains of Homer, and in the heroic poems of the early Hindus, which reflect the lofty and sublime character of eastern scenery.[1] As civilization advances, and man becomes more intellectual, language keeps pace in the progress. New words and new expressions are added, as new ideas occur and new things are invented, till at last language itself becomes a study, is refined and perfected by the introduction of general terms. The improvement in language and the development of the mind have been the same in all nations which have arrived at any degree of refinement, and shows the identity of human nature in every country and climate. The art of printing perpetuates a tongue, and great authors immortalize it; yet language is ever changing to a certain degree,

[1] Valmiki, the Hindu poet, is supposed to have been contemporary with Homer, if not his predecessor: his great work is the 'Ramayana,' an heroic poem of the highest order, four cantos of which have been translated by Gaspare Gorresco, an Italian. According to Dr. Pritchard, the four great dynasties of languages in the old continent are—the Indo-European or Indo-Germanic, now called the Arian or Iranian languages; the Turanian or Ugro-Tartarian, the language of high Asia; the Chinese and Indo-Chinese, or Monosyllabic; and the Syro-Arabian or Semitic languages. The three first are common to Europe and Asia; the fourth, common to Africa and some parts of Asia near Africa. The Arians are the ancient Medes and Persians; the Ugrians are the Fins, Laplanders, Hungarians, and many Siberian nations.

though it never loses traces of its origin. Chaucer and Spenser have become obscure; Shakespear requires a glossary for the modern reader; and in the few years that the United States of America have existed as an independent nation, the colloquial language has deviated from the mother-tongue. When a nation degenerates, it is split by jealousy and war into tribes, each of which in process of time acquires a peculiar idiom, and thus the number of dialects is increased, though they still retain a similarity; whereas when masses of mankind are united into great political bodies, their languages by degrees assimilate to one common tongue, which retains traces of all to the latest ages. The form of the dialects now spoken by some savage tribes, as the North American Indians, bears the marks of a once higher state of civilization.

More than 2000 languages are spoken, but few are independent; some are connected by words having the same meaning, some by grammatical structure, others by both; indeed the permanency of language is so great, that neither ages of conquest, nor mixing with other nations, have obliterated the native idiom of a people. The French, Spanish, and German retain traces of the common language spoken before the Roman conquest, and the Celtic tongue still exists in the British Islands.

By a comparison of their dialects, nations far apart, and differing in every other respect, are discovered to have sprung from a common, though remote origin. Thus all the numerous languages

spoken by the American Indians, or red men, are similar in grammatical structure: an intimate analogy exists in the languages of the Esquimaux nations who inhabit the arctic regions of both continents. Dialects of one tongue are spoken throughout North Africa, as far south as the oasis of Siwah on the east, and the Canary Islands on the west. Another group of cognate idioms is common to the inhabitants of Equatorial Africa, while all the southern part of the continent is inhabited by people whose languages are connected. The monosyllabic speech of the Chinese and Indo-Chinese shows that they are the same people; and all the insular nations of the Pacific derived their dialects from some tribes on the continent of India and the Indian Archipelago. Cognate tongues are spoken by the Tartars, Mandtchoux, Fins, Laplanders, many of the Siberian nations, and by the Hungarians.

The Persian, Arabic, Greek, Latin, German, and Celtic tongues are connected by grammatical structure, and words expressive of the same objects and feelings, with the Sanscrit, or sacred language of India; consequently the nations inhabiting that vast extent of country from the mouths of the Ganges to the British Isles, the coast of Scandinavia and Iceland, must have had the same origin. "The words that fall thoughtlessly from our lips in the daily vocations of life are no idle sounds, but magic symbols which preserve for ever the first migrations of the race, and whose antiquity makes Greece and Rome appear but of yesterday."

The number of languages spoken from the Ganges to Scandinavia, differing so widely from one another, is a proof of the strength of individual character in nations, which can so powerfully impress its peculiarities on the same mother tongue. In fact every nation, as well as every individual, has its own physical, moral, and intellectual organization, which influences its language and its whole existence.

In the Indo-Germanic nations, which have been dominant for ages, civilization has been progressive, though not without interruptions. Providence has endowed these nations with the richest and most ornamental gifts. Imagination has been liberally granted, and embodied in all that is sublime and beautiful in architecture, sculpture, painting, and poetry. In strength of intellect and speculation, in philosophy, science, laws, and the political principles of society, they have been pre-eminent.

The prevailing races of mankind now inhabiting Europe are the Teutonic, Celtic, and Sclavonian. In the greater part of the continent these races are mixed, but the blood is purely Teutonic throughout Iceland, Scandinavia, round the Gulf of Bothnia, in Denmark, Germany, and the east of England from Portsmouth to the Tyne. Pure Celtic blood is confined to the Basque Provinces in Spain, the south and south-west of France, a part of the Grisons and Switzerland, and some part of Great Britain. The Sclavonian blood is widely dispersed in middle Russia, from the Ural Mountains to the west of the Valdai table-land, and from Novogorod to the

lower course of the Don. The three races have been much improved by mixture, in appearance, energy, and versatility of mind.

It is extraordinary that nations should lose their vitality without any apparent cause; throughout the Indian Archipelago there is no longer any one great Malayan nation, in Europe pure Celtic blood has been on the decline for 20 centuries, and even the mixed Celtic variety has not increased in proportion to the Teutonic, although for 2000 years they have been exposed to the same external circumstances.

At present the Teutonic race, including the inhabitants of North America and the British colonies, considerably outnumber the Celtic, though its numbers were far inferior in ancient times. The Teutonic variety has subdued and even exterminated the other varieties in its progress towards the west; it is undoubtedly the most vigorous, both in body and mind, of all mankind, and seems destined to conquer and civilize the whole world. It is a singular fact, whatever the cause may be, that the Celts are invariably Catholic, while the Teutonic population is inclined to Protestantism.

Various other races inhabit Europe, much inferior in numbers to those above mentioned, though occasionally mixed with them, as the Turks, Fins, the Samojedes, who live on the shores of the White Sea and in the north-east of Russia, and the Hungarians, the higher class of which are a fine race of men, and on a par with the most civilized of the European nations. There are many mixed Tartar

tribes, chiefly in the south and east of the Russian territories; also Jews and Gipsies, who live among all nations, yet mix with none.[1]

[1] EUROPEAN POPULATION.

Pure blood.

Teutonic	52,000,000
Sclavonian	50,000,000
Celtic	12,000,000
Magyar	9,000,000
Fins and Samojedes	3,000,000
Tatar	2,000,000
Jews	2,000,000
Total European population of pure blood	130,000,000

Mixed blood in Europe.

Teutonic Celtic	22,000,000
Teutonic Sclavonian	6,000,000
Teutonic mixed with Walloons in Belgium	1,200,000
Teutonic Northmen in Normandy	1,500,000
Celtic in its different crosses	56,000,000
Sclavonian	6,000,000
Lettons	2,000,000
Turks	4,000,000
Turco-Tatar-Sclavonic in centre, south-east, and east of Russia	2,600,000
Kalmuk, between the rivers Volga and Ural	300,000
The number of people of mixed blood in Europe	101,600,000

The total population of Europe, pure and mixed, amounts to about 232 millions, including 600,000 Gipsies. The Teutonic population in the United States of North America and in the British colonies amounts to 20 millions; so that the total number of people of Teutonic blood is rather more than 100 millions.—Notes accompanying the Ethnographic Map of Europe, by Dr. Gustaf Kombst: 'Phys. Atlas.'

The inhabitants of Great Britain are of Celtic and Teutonic origin. The Celtic blood is purest in Cornwall and the Scilly Islands, in Wales, and the Isle of Man: in the highlands of Scotland and the Hebrides it is more mixed than is generally supposed, as plainly appears from the frequency of red hair and blue eyes. In some parts of Ireland there is pure Celtic blood, but throughout the greater part of that country it is mixed, although the Celtic character predominates; but in Ulster, where the earliest colony settled, the blood is purely Teutonic. In Ireland the difference in the organization of the two races is strongly marked: placed under the same circumstances, the Teutonic part of the population has prospered, which, unfortunately, has not been the case with the Celtic.[1]

[1] POPULATION OF GREAT BRITAIN AND IRELAND.

On an average the pure-blooded population amounts to

Teutonic in England, Scotland, and in the east and north-east of Ireland .	10,000,000
Celtic in Cornwall, Wales, the Scottish Highlands, and Ireland . . .	6,000,000
The pure-blooded inhabitants amounts to	16,000,000

Mixed blood.

Mixture in which the Teutonic blood predominates	6,000,000
Mixture in which the Celtic blood predominates	4,000,000
	10,000,000

In all 26,000,000 of inhabitants.

Notes accompanying the Ethnographic Map of Great Britain and Ireland, by Gustaf Kombst: 'Phys. Atlas.'

The fear that Britain may be ruined by over population

The dialects spoken in the Celtic districts are closely allied to the Semitic languages of Asia, and to one another. The Cornish is worn out, the Manx is nearly so, and the Gaelic is declining fast in the highlands of Scotland.

The Roman invasion had no effect on the Anglo-Saxon or old English, a language of Teutonic origin, but the Normans in ancient times had altered it considerably, and in modern times the English tongue has unfortunately been corrupted by the introduction of French, Latin, and Latinized words. Scotch spoken throughout the Lowlands of Scotland is a language independent of the English, though of the same stock; it is derived from the low German, the Frisian, Dutch, and Flemish, and differs widely from the Anglo-Saxon.

No circumstance in the natural world is more inexplicable than the diversity of form and colour in the human race. It had already begun in the antediluvian world, for "there were giants in the land in those days." No direct mention is made of colour at that time, unless the mark set upon Cain, "lest any one finding him should kill him," may allude to it. Perhaps, also, it may be inferred that black people dwelt in Ethiopia, or the land of Cush, which means black in the Hebrew language. At all events, the

may be allayed by considering that we are ignorant of the immense treasures and inexhaustible resources of the natural world—that the ingenuity of man is infinite, and will continually discover new powers and innumerable combinations that will furnish sources of wealth and happiness to millions.

difference now existing must have arisen after the flood, consequently all must have originated with Noah, whose wife, or the wives of his sons, may have been of different colours, for aught we know.

Many instances have occurred in modern times, of albinos and red-haired children having been born of black parents, and these have transmitted their peculiarities to their descendants for several generations, but it may be doubted whether pure-blooded white people have had perfectly black offspring. The varieties are much more likely to have arisen from the effects of climate, food, customs, and civilization upon migratory groups of mankind; and of such, a few instances have occurred in historical times, limited, however, to small numbers and particular spots; but the great mass of nations had received their distinctive characters at a very early period. The permanency of type is one of the most striking circumstances, and proves the length of time necessary to produce a change in national structure and colour. A nation of Ethiopians existed 3450 years ago, which emigrated from a remote country and settled near Egypt, and there must have been black people before the age of Solomon, otherwise he would not have alluded to colour, even poetically. The national appearance of the Ethiopians, Persians, and Jews, has not varied for more than 3000 years, as appears from the ancient Egyptian paintings in the tomb of Rhameses the Great, discovered at Thebes by Belzoni, in which the countenance of the modern Ethiopian and Persian can be readily recognised,

and the Jewish features and colour are identical with those of the Israelites daily met with in London. Civilization is supposed to have great influence on colour, having a tendency to make the dark shade more general, and it appears that, in the crossing of two shades, the offspring takes the complexion of the darker and the form of the fairer. But as there is no instance of a new variety of mankind having been established as a nation since the Christian era, there must either have been a greater energy in the causes of change before that time, or, brief as the span of man on earth has been, a wrong estimate of time antecedent to the Christian period must have made it shorter.[1]

Darkness of complexion has been attributed to the sun's power from the age of Solomon to this day—"Look not upon me, because I am black, because the sun hath looked upon me;" and there can be no doubt that, to a certain degree, the opinion is well

[1] From the discrepancies in the chronological systems it is evident that the actual period of man's creation is not accurately known. The Chevalier Bunsen has ascertained from monumental inscriptions, that the successive Egyptian dynasties may be traced back to Meres, 3640 years before the Christian era, and from the high state of civilization during the reign of that prince, proved by the magnificence of the works thus executed, he infers that the Egyptians must have existed 500 years previous to their consolidation into one empire by him, which goes back to the renewed period of man's creation. Compared with geological periods, man is of very recent creation, as appears from the vast extent of uninhabited land, but which would require ages and ages to people, even if the increase of population were as rapid as in the United States of North America.

founded. The invisible rays in the solar beams, which change vegetable colours, and have been employed with such remarkable effect in the Daguerreotype, act upon every substance on which they fall, producing mysterious and wonderful changes in their molecular state—man not excepted.[1]

Other causes must have been combined to occasion all the varieties we now see, otherwise every nation between the tropics would be of the same hue, whereas the sooty Negro inhabits equatorial Africa, the Red man equinoctial America, and both are mixed with fairer tribes. In Asia, the Rohillas, a fair race of Affghan extraction, inhabit the plains north of the Ganges: the Bengalee and the mountaineers of Nepaul are dark, and the Mahrattas are yellow. The complexion of man varies with height and latitude; some of the inhabitants of the Himalaya and Hindoo Koosh are fair, and even a red-haired race is found on the latter. There are fair-haired people with blue eyes in the Ruddhua mountains in Africa. The Kabyles, that inhabit the country behind Tunis and Algiers, are similar in complexion to the nations in high northern latitudes. This correspondence, however, only maintains with regard to the northern hemisphere, for it is a well-known fact that the varieties of the numerous species

[1] Dark-coloured substances absorb more of the sun's heat than light-coloured ones; therefore, the black skins of the natives of tropical climates absorb more heat than fair skins, but, from some unknown cause, the black skin is protected from a degree of heat that would blister a fair one.

in the great southern continents are much more similar in physical characters to the native races of the torrid zone, than any of the aboriginal people of the northern regions. Even supposing that diversity of colour is owing to the sun's rays only, it is scarcely possible to attribute the thick lips, the woolly hair, and the entire difference of form, extending even to the very bones and skull, to anything but a concurrence of circumstances, not omitting the invisible influence of electricity, which pervades every part of the earth and air—and possibly terrestrial magnetism.

The flexibility of man's constitution enables him to live in every climate, from the equator to the ever-frozen coasts of Nova Zembla and Spitzbergen, and that chiefly by his capability of bearing the most extreme changes of temperature and diet, which are probably the principal causes of the variety in his form. It has already been mentioned that oxygen is inhaled with the atmospheric air, and also taken in by the pores on the skin; part of it combines chemically with the carbon of the food, and is expired in the form of carbonic acid gas and water; that chemical action is the cause of vital force and heat in man and animals. The quantity of food must be in exact proportion to the quantity of oxygen inhaled, otherwise disease and loss of strength would be the consequence. Since cold air is incessantly carrying off warmth from the skin, more exercise is requisite in winter than in summer, in cold climates than in warm; consequently more carbon is neces-

sary in the former than in the latter, in order to maintain the chemical action that generates heat, and to ward off the destructive effects of the oxygen, which incessantly strives to consume the body. Animal food, wine, and spirits, contain many times more carbon than fruit and vegetables, therefore animal food is much more necessary in a cold than in a hot climate. The Esquimaux, who lives by the chace, and eats 10 or 12 pounds weight of meat and fat in 24 hours, finds it not more than enough to keep up his strength and animal heat, while the indolent inhabitant of Bengal is sufficiently supplied with both by his rice diet. Clothing and warmth make the necessity for exercise and food much less, by diminishing the waste of animal heat. Hunger and cold united soon consume the body, because it loses its power of resisting the action of the oxygen, which consumes part of our substance, when food is wanting. Hence nations inhabiting warm climates have no great merit in being abstemious, nor are those guilty of committing an excess who live more freely in colder countries. The arrangement of Divine Wisdom is to be admired in this as in all other things, for, if man had only been capable of living on vegetable food, he never could have had a permanent residence beyond the latitude where corn ripens. The Esquimaux, and all the inhabitants of the very high latitudes of both continents, live entirely on fish and animal food. What effects the difference of food may have upon the intellect is not known.

A nation or tribe driven by war, or any other cause, from a warm to a cold country, or the contrary, would be forced to change their food both in quality and quantity, which in the lapse of ages might produce an alteration in the external form and internal structure. The probability is still greater, if the entire change that a few years produces in the matter of which the human frame is composed be considered. At every instant during life, with every motion, voluntary and involuntary, with every thought and every exercise of the brain, a portion of our substance becomes dead, separates from the living part, combines with some of the inhaled oxygen, and is removed. By this process it is supposed that the whole body is renewed every 7 years; individuality, therefore, depends on the spirit, which retains its identity during all the changes of its earthly house, and sometimes even acts independently of it. When sleep is restoring exhausted nature, the spirit is often awake and active, crowding the events of years into a few seconds, and, by its unconsciousness of time, anticipates eternity. Every change of food, climate, and mental excitement must have their influence on the reproduction of the mortal frame; and thus a thousand causes may co-operate to alter whole races of mankind placed under new circumstances, time being granted.

The difference between the effects of manual labour and the efforts of the brain appears in the intellectual countenance of the educated man, com-

pared with that of the peasant, though even he is occasionally stamped with nature's own nobility. The most savage people are also the ugliest. Their countenance is deformed by violent unsubdued passions, anxiety, and suffering. Deep sensibility gives a beautiful and varied expression, but every strong emotion is unfavourable to perfect regularity of feature; and of that the Greeks were well aware when they gave that calmness of expression and repose to their unrivalled statues. The refining effects of high culture, and, above all, the Christian religion, by subduing the evil passions, and encouraging the good, are more than anything calculated to improve even the external appearance. The countenance, though perhaps of less regular form, becomes expressive of the amiable and benevolent feelings of the heart, the most captivating and lasting of all beauty.[1]

Thus an infinite assemblage of causes may be assigned as having produced the endless varieties in the human race; but the fact remains an inscrutable mystery. But amidst all the physical vicissitudes man has undergone, the species remains permanent; and let those who think that the difference in the

[1] The countenances of the Fuegians brought to England in 1830 by Captain FitzRoy improved greatly in expression by their intercourse with civilized men, but they had not returned to their savage brethren more than a year before their whole appearance was completely changed; the look of intelligence they had acquired was gone; and when compared with likenesses that had been taken of them when in England, they were not to be recognised as the same persons.

species of animals and vegetables arises from diversity of conditions, consider, that no circumstances whatever can degrade the form of man to that of the monkey—or elevate the monkey to the form of man.

Animals and vegetables, being the sources of man's sustenance, have had the chief influence on his destiny and location, and have induced him to settle in those parts of the world where he could procure them in greatest abundance. Wherever the chace or the spontaneous productions of the earth supply him with food, he is completely savage, and only a degree further advanced where he plants the palm and the banana; where grain is the principal food, industry and intelligence are most perfectly developed, as in the temperate zone. On that account the centres of civilization have generally been determined, not by a hot, but by a genial climate, fertile soil, by the vicinity of the sea-coast or great rivers, affording the means of fishing and transport, which last has been one of the chief causes of the superiority of Europe and Southern Asia. The mineral treasures of the earth have been the means of assembling great masses of men in Siberia and the table-land of the Andes, and have given rise to many great cities, both in the Old and the New World. Nations inhabiting elevated table-lands and high ungenial latitudes have been driven there by war, or obliged to wander from countries where the population exceeded the means of living—a cause of migration to which both language and

tradition bear testimony. The belief in a future state, so universal, shown by respect for the dead, has no doubt been transmitted from nation to nation. The American Indians, driven from their hunting-grounds, still make pilgrimages to the tombs of their fathers; and these tribes alone, of all uncivilized mankind, worship the Great Spirit as the invisible God and Father of all—a degree of abstract refinement which could hardly have sprung up spontaneously among a rude people, and which must have been transmitted from races who held the Jewish faith.

It is probable that America had been peopled from Asia before the separation of the continents by Behring's Straits, and there is reason to believe that the location of various races of mankind, now insulated, may have taken place before the separation of the lands by mediterranean seas; whilst others, previously insulated, may be now united by the drying up of inland seas, as those which covered the Sahara desert, and the great hollow round the Caspian Sea, of which it and the Black Sea are probably the remnants.

M. Boué has observed that mountain chains running nearly east and west establish much more striking differences among nations than those which extend from north to south—a circumstance confirmed by observation through the history of mankind. The Scandinavian Alps have not prevented the countries on both sides from being occupied by people of a common descent; while the feeble barrier of the

Cheviot Hills, between England and Scotland, and the moderate elevation of the Highland mountains, have prevented the amalgamation of the Anglo-Saxons and the Celts, even in a period of high civilization. The Franks and Belgians are distinct, though separated by hills of still less elevation. For the same reason the Spaniards and Italians differ far more from their neighbours on the other side of the eastern and western chains, than the Spaniards do from the Portuguese, or the Piedmontese from the Provençals. A similar distinction prevails throughout Asia; and in America, where all the principal chains run north and south, there is but one copper-coloured race throughout the continent, which stretches over more climates than Europe and Africa, or even than Asia and Australia, united. It is along chains running north and south that the fusion of languages takes place, and not along those of an easterly and westerly direction. From Poland, for instance, there are intermediate insensible gradations through Germany into France; while in crossing from a German district of the Alps to the valleys of Italy, different tribes and different languages are separated by a single mountain. Even wars and conquest have ever been more easy in one direction than in the other. The difference in the fauna and flora on the two sides of the great table-land and mountains of Asia is a striking illustration of the influence which high lands running east and west have on natural productions, and thus, both directly and indirectly, they affect the distribution of mankind.

The circumstances which thus determine the location of nations, and the fusion or separation of their languages, must, conjointly with moral causes, operate powerfully on their character. The minds of mankind, as well as their fate, are influenced by the soil on which they are born and bred. The natives of elevated countries are attached to their mountains; the Dutch are as much attached to their meadows and canals; and the savage, acquainted only with the discomforts of life, is unhappy when brought among civilized man. Early associations never entirely leave us, however much our position in life may alter, and strong attachments are formed to places which generate in us habits differing from those of other countries.

The Baltic and Mediterranean Seas have had no inconsiderable share in civilizing Europe; one combined with a cold and gloomy climate, the other with a warm and glowing sky, have developed dissimilar characters in the temperament and habits of the surrounding nations, originally dissimilar in race. The charms of climate and the ease with which the necessaries of life are procured were favourable to the development of imagination in the more southern nations, and to an indolent enjoyment of their advantages. In the north, on the contrary, the task imposed upon man was harder, and perhaps more favourable to strength of character. The Dutch owe their industry and perseverance to their unceasing struggle against the encroachments of the ocean; the British are indebted to their insular position for their mari-

time disposition, and to the smallness of their country and the richness of their mines, for their manufacturing and colonizing habits; the military propensities of the French, to the necessity of maintaining their independence among the surrounding nations, as well as to ambition and the love of fame.

Thus external circumstances materially modify the character of nations, but the original propensities of race are never eradicated, and they are nowhere more prominent than in the progress of the social state in France and England. The vivacity and speculative disposition of the Celt appear in the rapid and violent changes of government and in the succession of theoretical experiments in France; while in Britain the deliberate slowness, prudence, and accurate perceptions of the Teuton are manifest in the gradual improvement and steadiness of their political arrangements. "The prevalent political sentiment of Great Britain is undoubtedly *conservative*, in the best sense of the word, with a powerful under-current of *democratic tendencies*. This gives great power and strength to the political and social body of this country, and makes revolutions by physical force almost impossible. It can be said, without assumption or pretension, that the body politic of Britain is in a sounder state of health than any other in Europe; and that those know very little of this country, who, led away by what they see in France, always dream of violent and revolutionary changes in the constitution. Great Britain is the only country in Europe which has had the good fortune to have all her insti-

tutions worked out and framed by her in a strictly *organic* manner—that is, in accordance with *organic wants*, which require different *conditions* at different and *successive* stages of national development—and not by *theoretical experiments*, as in many other countries which are still in a state of excitement consequent upon these experiments. The social character of the people of this country, besides the features which they have in common with other nations of Teutonic origin, is, on the whole, domestic, reserved, aristocratic, and exclusive."[1]

In speculating upon the effects of external circumstances, and on the original dispositions of the different races of mankind, the stationary and unchanged condition is a curious phenomenon in the history of nations. The inhabitants of Hindostan have not advanced within the historical period; neither have the Chinese. The Peruvians and Mexicans had arrived

[1] Johnston's 'Physical Atlas.'

The average age of a nation, or the mean duration of life, has a considerable influence on the character of a people. The average age of the population of England and Wales is 26 years 7 months. By the census the average age of the population of the United States of North America is 22 years 2 months. In England there are 1365 persons in every 10,000, who have attained 50 years of age, and consequently of experience; while in the United States only 830 in each 10,000 have arrived at that age: hence in the United States the moral predominance of the young and passionate is greatest. In Ireland there are 1050 persons in every 10,000 of the population, above 50 years of age, to exercise the influence of their age and experience upon the community—an influence that will diminish with the progress of emancipation.

at a considerable degree of civilization, at which they became stationary, never having availed themselves of their fine country and noble rivers; and their conquerors, the Spaniards, degenerated into the same apathy with the conquered. The unaccountable gipsies have for ages maintained their peculiarities in all countries; so have the Jews and Armenians, who by the perseverance with which they have adhered to their language and institutions, have resisted the influence of physical impressions.

The influence of external circumstances on man is not greater than his influence on the material world. He cannot create power, it is true, but he dexterously avails himself of the powers of nature to subdue nature. Air, fire, water, steam, gravitation, his own muscular strength, and that of animals rendered obedient to his will, are the instruments by which he has converted the desert into a garden, drained marshes, cut canals, made roads, turns the course of rivers, cleared away forests in one country, and planted them in another. By these operations he has altered the climate, changed the course of local winds, increased or diminished the quantity of rain, and softened the rigour of the seasons. In the time of Strabo, the cold in France was so intense, that it was thought impossible to ripen grapes north of the Cevennes: the Rhine and the Danube were every winter covered with ice thick enough to bear any weight. Man's influence on vegetation has been immense, but the most important changes had been effected in the antediluvian ages of the world. Cain was a tiller of

the ground. The olive, the vine, and the fig-tree have been cultivated time immemorial: wheat, rice, and barley, have been so long in an artificial state, that their origin is unknown; even maize, which is a Mexican plant, was in use among the American tribes before the Spanish conquest; and tobacco was already used by them to allay the pangs of hunger, to which those who depend upon the chace for food must be exposed. Most of the ordinary culinary vegetables have been known for ages, and it is remarkable that in these days, when our gardens are adorned with innumerable native plants in a cultivated state, few new grains, vegetables, or fruits have been reclaimed; the old have been produced in infinite variety, and many brought from foreign countries: yet there must exist many plants capable of cultivation, as unpromising in their wild state as the turnip or carrot.

Some families of plants are more susceptible of improvement than others, and, like man himself, can bear almost any climate. One kind of wheat grows to 62° N. latitude; rye and barley are hardier, and succeed still farther north; and few countries are absolutely without grass. The cruciform tribe abounds in useful plants, indeed that family, together with the solanum, the papilionaceous and umbelliferous tribes, furnish most of our vegetables. Many plants, like animals, are of one colour only in their wild state, and their blossoms are single. Art has introduced the variety we now see in the same species, and, by changing the anthers of the mild flowers into petals,

has produced double blossoms: by art, too, many plants, natives of warm countries, have been naturalized in colder climates. Few useful plants have beautiful blossoms—but if utility were the only object, of what pleasure should we be deprived! Refinement is not wanting in the inmates of a cottage covered with roses and honeysuckle; and the little garden cultivated amidst a life of toil, tells of a peaceful home.

Among the objects which tend to the improvement of our race, the flower-garden and the park adorned with native and foreign trees have no small share: they are the greatest ornaments of the British Islands; and the love of a country life, which is so strong a passion, is chiefly owing to the law of primogeniture, by which the head of a family is secured in the possession and transmission of his undivided estate, and therefore each generation takes pride and pleasure in adorning the home of its forefathers.

Animals yield more readily to man's influence than vegetables, and certain classes have greater flexibility of disposition and structure than others. Those only are capable of being perfectly reclaimed that have a natural tendency for it, without which man's endeavours would be unavailing. This predisposition is greatest in animals which are gregarious and follow a leader, as elephants, dogs, horses, and cattle do in their wild state; yet even among these some species are refractory, as the buffalo, which can only be regarded as half-reclaimed. The canine tribe, on the contrary, are capable of the greatest attachment,

not the dog only, man's faithful companion, but even the wolf, and especially the hyæna, generally believed to be so ferocious. After an absence of many months, a hyæna which had been the fellow-passenger of a friend of the author's in a voyage from India, recognised his voice before he came in sight, and on seeing him it showed the greatest joy, lay down like a dog and licked his hands. He had been kind to it on the voyage, and no animal forgets kindness, which is the surest way of reclaiming them. There cannot be a greater mistake than the harsh and cruel means by which dogs and horses are too commonly trained; but it is long before man learns that his power is mental, and that it is his intellect alone that has given him dominion over the earth and its inhabitants, of which so many far surpass him in physical strength. The useful animals were reclaimed by the early inhabitants of Asia, and it is very remarkable, notwithstanding the enterprise and activity of the present times, that among the multitudes of animals that inhabit America, Central and Southern Africa, Australia and the Indian Archipelago, 4 only have been domesticated, yet many may be capable of becoming useful to man. Of 35 species of which we possess one or more domestic races, 31 are natives of Asia, Europe, and North Africa; these countries are far from being exhausted, and a complete hemisphere is yet unexplored. An attempt has been made to domesticate the Llama, the Dziggetai, Zebra, and some species of Indian deer, but the success is either doubtful or the attempt has not been followed up. Little has

been left for modern nations but the improvement of the species, and in that they have been very successful. The variety of horses, dogs, cattle, and sheep is beyond number. The form, colour, and even the disposition, may be materially altered, and the habits engrafted are transmitted to the offspring, as instinctive properties independent of education. Domestic fowls go in flocks on their native meads when wild. There are, however, instances of solitary birds being tamed to an extraordinary degree, as the raven, one of the most sagacious.

Man's necessities and pleasure have been the cause of great changes in the animal creation—and his destructive propensity of still greater. Animals are intended for our use, and field-sports are advantageous by encouraging a daring and active spirit in young men, but the utter destruction of some races, in order to protect those destined for his pleasure, is too selfish. Animals soon acquire a dread of man, which becomes instinctive and hereditary; in newly discovered uninhabited countries, birds and beasts are so tame as to allow themselves to be caught; whales scarcely got out of the way of the ships that first navigated the Arctic Ocean, but now they universally have a dread of the common enemy: whales and seals have been extirpated in various places; sea-fowl and birds of passage are not likely to be extinguished, but many land animals and birds are vanishing before the advance of civilization. Drainage, cultivation, cutting down of forests, and even the introduction of new plants and animals, destroy some of the old, and

alter the relations between those that remain. The inaccessible cliffs of the Himalaya and Andes will afford a refuge to the eagle and condor, but the time will come when the mighty forests of the Amazons and Orinoco will disappear with the myriads of their joyous inhabitants. The lion, the tiger, and the elephant will be known only by ancient records. Man, the lord of the creation, will extirpate the noble creatures of the earth—but he himself will ever be the slave of the canker-worm and the fly. Cultivation may lessen the scourge of the insect tribe, but God's great army will ever, from time to time, appear suddenly—no one knows from whence; the grub will take possession of the ground, and the locust will come from the desert and destroy the fairest prospects of the harvest.

Though the unreclaimed portion of the animal creation is falling before the progress of improvement, yet man has been both the voluntary and the involuntary cause of the introduction of new animals and plants into countries in which they were not natives. The Spanish conquerors little thought that the descendants of the few cattle and horses they allowed to run wild, would resume the original character of their species, and roam in hundreds of thousands over the savannahs of South America. Wherever man is, civilized or savage, there also is the dog, but he too has in some places resumed his native state and habits, and hunts in packs. Domestic animals, grain, fruit, vegetables, and the weeds that grow with them, have been conveyed by colonists to all

settlements. Birds and insects follow certain plants into countries in which they were never seen before. Even the inhabitants of the waters change their abode in consequence of the influence of man. Fish, natives of the rivers on the coast of the Mexican Gulf, have migrated by the canals to the heart of North America; and the mytilus polymorphus, a shell-fish brought to the London Docks in the timbers of ships from the brackish waters of the Black Sea and its tributary streams, has spread into the interior of England by the Croydon and other canals.

The influence of man on man is a power of the highest order, far surpassing that which he possesses over inanimate or animal nature. It is, however, as a collective body, and not as an individual, that he exercises this influence over his fellow-creatures. The free-will of man, nay, even his most capricious passions, neutralize each other, when large numbers of men are considered. Professor Quetelet has most ably proved, that the greater the number of individuals, the more completely does the will of each, as well as all individual peculiarities, moral or physical, disappear, and allow the series of general facts to predominate, which depend upon the causes by which society exists and is preserved. The uniformity with which the number of marriages in Belgium occurred in 20 years, places the neutralization of the free-will of the individual man beyond a doubt, and is one of many instances of the importance of average quantities in arriving at general laws.

Certainly no event in a man's life depends more upon his free will than his marriage, yet it appears from the records in Brussels, that nearly the same number of marriages take place every year, in the towns as well as in the country, and moreover that the same constancy prevails in each province, though the numbers of the people are so small, that accidental causes might be more likely to affect the general result than when the numbers are larger. In fact the whole affair passes as if the inhabitants of Belgium had agreed to contract nearly the same number of marriages annually, at each stage of life. Young people may possibly be in some degree under the control of parents, but there can be no restraint on the free will of men of 30 and women of 60 years of age, yet the same number of such incongruous marriages do annually take place between men and women at those unsuitable ages—a fact which almost exceeds belief. The day fixed for a wedding is of all things most entirely dependent on the will of the parties, yet even here there is regularity in the annual recurrence. (See Table on next page.)

With regard to crimes also, M. Quetelet observes that the same number of crimes of the same description are committed annually, with remarkable uniformity, even in the case of those crimes which would seem most likely to baffle all attempt at prediction. The same regularity occurs in the sentences passed on criminals: in France, in every hundred trials there were sixty-one convictions regularly, year after year.

Forgetfulness, as well as free-will, is under constant laws: the number of undirected letters put into

The following Table, which is one of the most curious of statistical documents, was formed by Professor Quetelet from the Register of Marriages at Brussels:—

MARRIAGES IN BELGIUM IN THE YEARS

		1841	1842	1843	1844	1845
Men of 30 years of age and under, to	Women of 30 years of age and under	12,788	12,422	12,368	13,024	13,157
	Women from 30 to 45	2,630	2,626	2,406	2,375	2,438
	Women from 45 to 60	93	121	125	129	102
	Women from 60 upwards	7	6	8	5	5
Men from 30 to 45 inclusive, to	Women of 30 and under	6,122	5,803	5,617	4,948	5,810
	Women from 30 to 45	5,531	5,396	5,100	5,205	4,981
	Women from 45 to 60	529	542	479	493	532
	Women from 60 upwards	18	12	18	21	21
Men from 45 to 60 inclusive, to	Women of 30 and under	376	346	380	355	346
	Women from 30 to 45	896	879	896	951	993
	Women from 45 to 60	461	447	433	462	460
	Women from 60 upwards	23	19	29	36	28
Men from 60 and above, to .	Women of 30 and under	48	35	45	41	36
	Women from 30 to 45	139	147	133	119	125
	Women from 45 to 60	153	170	137	112	145
	Women from 60 upwards	62	52	48	50	31
Annual Number of Marriages		29,876	29,023	28,220	29,326	29,210

the post-office in London and in Paris is very nearly the same year after year respectively—in London they amount to 2000: so that even the deviations from free-will proves the generality and the constancy of the laws that govern us.

Scientific discoveries and social combinations, which put in practice great social principles, are not without a decided influence; but these causes of action, coming from man, are placed out of the sphere of the free-will of each: so that individual impulse has less to do with the progress of mankind than is generally believed. When society has arrived at a certain point of advancement, certain discoveries will naturally be made; the general mind is directed that way, and if one individual does not hit upon the discovery, another will. Therefore on the disputes and discussions of different nations for the honour of particular inventions or discoveries, as for example the steam-engine, a narrow view of the subject is taken; they properly belong to the age in which they are made, without derogating from the merits of those benefactors of mankind who have lessened his toil or increased his comfort by the efforts of their genius. The time had come for the invention of printing, and printing was invented; and the same observation is applicable to many objects in the physical, as well as to the moral world. In the present disturbed state of society the time is come for the termination of the feudal system, which will be swept away by the force of public opinion, though individuality merges in these general movements.

Though each individual is accountable to God for his conduct, it is évident that the great laws which regulate mankind are altogether independent of his will, and that liberty of action is perfectly compatible with the general design of Providence. "A more profound study of the social system will have the effect of limiting more and more the sphere in which man's free-will is exercised, for the Supreme Being could not grant him a power which tends to overthrow the laws impressed on all the parts of creation: He has traced its limits, as He has fixed those of the ocean."

Man is eminently sociable; he willingly gives up part of his free-will to become a member of a social body; and it is this portion of the individuality of each member of that body, taken in the aggregate, which becomes the directrice of the principal social movements of a nation. It may be greater or less, good or bad, but it determines the customs, wants, and the national spirit of a people; it regulates the sum of their moral statistics; and it is in that manner that the cultivation or savageness, the virtues or the vices, of individuals have their influence. It is thus that private morality becomes the base of public morality.

The more man advances in civilization the greater will be his collective influence, for knowledge is power; and at no time did the mental superiority of the cultivated races produce such changes as they do at present, because they have extended their influence to the uttermost parts of the earth by emigration,

colonization, and commerce. In civilized society the number of people in the course of time exceeds the means of sustenance, which compels some to emigrate; others are induced by a spirit of enterprise to go to new countries, some for the love of gain, others to fly from oppression.

The discovery of the New World opened a wide field for emigration. Spain and Portugal, the first to avail themselves of it, acquired dominion over some of the finest parts of South America, which they have maintained till lately a change of times has rendered their colonies independent states. Liberal opinions have spread into the interior of that continent, in proportion to the facility of communication with the cities on the coasts, from whence European ideas are disseminated. Of this Venezuela and Chile are instances, where civilization and prosperity have advanced more rapidly than in the interior parts of South America, where the Andes are higher and the distance from the sea greater. Civilization has been impeded in many of the smaller states by war, and those broils inevitable among people unaccustomed to free institutions. Brazil would have been further advanced but for slavery, that stain on the human race, which corrupts the master as much as it debases the slave.

Some of the native South American tribes have spontaneously made considerable progress in civilization in modern times; others have benefited by the Spanish and Portuguese colonists; and many have been brought into subjection by the Jesuits, who

have instructed them in some of the arts of social life. But these Indians are not more religious than their neighbours, and, from the restraint to which they have been subject, have lost vigour of character without improving in intellect; so that now they are either stationary or retrograde. Extensive regions are still the abode of men in the lowest state of barbarism: some of the tribes inhabiting the silvas of the Orinoco, Amazons, and Uruguay are cannibals.

The arrival of the colonists in North America sealed the fate of the red men. The inhabitants of the Union, too late awakened to the just claims of the ancient proprietors of the land, have recently, but vainly, attempted to save the remnant. The white man, like an irresistible torrent, has already reached the centre of the continent; and the native tribes now retreat towards the far west, and will continue to retreat, till the Pacific Ocean arrests them, and the animals on their hunting-grounds are exterminated. The almost universal dislike the Indian has shown for the arts of peace has been one of the principal causes of his decline, although the Cherokee tribe, which has lately migrated to the west of the Mississippi, is a remarkable exception; the greater number of them are industrious planters or mechanics; they have a republican government, and publish a newspaper in their own language, in a character lately invented by one of that nation.

No part of the world has been the scene of greater iniquity than the West Indian islands—and that perpetrated by the most enlightened nations of Europe.

The native race has long been swept away by the stranger, and a new people, cruelly torn from their homes, have been made the slaves of hard task-masters. If the odious participation in this guilt has been a stain on the British name, the abolition of slavery by the universal acclamation of the nation will ever form one of the brightest pages in their history, so full of glory ; nor will it be the less so, that justice was combined with mercy, by the millions of money granted to indemnify the proprietors. It is deeply to be lamented that our brethren on the other side of the Atlantic have not followed the example of their fatherland ; but in limited monarchies the voice of the people is listened to, while republican governments are more apt to become its slave. The Northern States have nobly declared every man free who sets his foot on their territory—and the time will come when the Southern States will sacrifice interest to justice and mercy.

It seems to be the design of Providence to supplant the savage by civilized man in the continent of Australia as well as in North America, though every effort has been made to prevent the extinction of the natives. Most of the tribes in that continent are as low in the scale of mankind as the cannibal Fuegians whom Captain Fitzroy so generously, but so ineffectually, attempted to reclaim. Some of the New Hollanders are faithful servants for a time, but they almost always find the restraint of civilized life irksome, and return to their former habits, though truly miserable in a country where the means of existence

are so scanty. Animals and birds are very scarce, and there is no fruit or vegetable for the sustenance of man.

Slavery has been a greater impediment to the improvement of Africa than even the physical disadvantages of the country—the great arid deserts and unwholesome coasts. A spontaneous civilization has arisen in various parts of Southern and Central Africa, in which there has been considerable progress in agriculture and commerce; but civilized man has been a scourge on the Atlantic coast, which has extended its baneful influence into the heart of the continent, by the encouragement it has given to warfare among the natives for the capture of slaves, and for the introduction of European vices, unredeemed by Christian virtues. Now that France and England have united in the suppression of this odious traffic, some hopes may be entertained that their colonies may be beneficial to the natives, and that other nations may follow their example, in which, however, they have been anticipated by three Mohammedan sovereigns; the Sultan has abolished the slave-market in Constantinople, Ibrahim Pasha on his return from France and England gave freedom to his bondsmen in Egypt, and the Bey of Tunis has abolished slavery in his dominions.

The French are zealous in improving the people in Algiers, but the constant warfare in which they have been embroiled ever since their conquest must render their success in civilizing the natives at least remote. The inhabitants of those extensive and

magnificent countries in the eastern seas that have long been colonized by the Dutch have made but little progress under their rule.

The British colony at the Cape of Good Hope has had considerable influence on the neighbouring rude nations, who now begin to adopt more civilized habits. When Mr. Somerville visited Litako, the natives for the first time saw a white person and a horse, and were scantily clothed with skins. When Dr. Smith visited them 20 years afterwards, he found the chief men mounted on horseback, wearing hats made of rushes, and an attempt made to imitate European dress.

Colonization has nowhere produced such happy results as among the amiable and cultivated inhabitants of India, who are sensible of the benefits they derive from the impartial administration of just and equal laws, the foundation of schools and colleges, and the wide extension of commerce.

All the causes of emigration have operated by turns on the inhabitants of Britain, and various circumstances have concurred to make their colonies permanent. In North America, that which not many years ago was a British colony has become a great independent nation, occupying a large portion of the continent. The Australian continent and New Zealand will in after ages be peopled by a British race, and will become centres of civilization which will spread its influence to the uttermost islands of the Pacific. These splendid islands, possessing every advantage of climate and soil, with a population in many parts

far advanced in the arts of civilized life, industry, and commerce, though in others savage, will in time come in for a share of the general improvement. The success that has attended the noble and unaided efforts of Sir J. Brooke in Borneo, shows how much the influence of an active and benevolent mind can in a short time effect.

The colonies on the continent of India are already centres from which the culture of Europe is spreading over the East.

Commerce has not less influence on mankind than colonization, with which it is intimately connected; and the narrow limits of the British Islands have rendered it necessary for its inhabitants to exert their industry. The riches of our mines in coal and metals, which produce a yearly income of 24,000,000*l.* sterling, is a principal cause of our manufacturing and commercial wealth; but even with these natural advantages, more is due not only to our talents and enterprise, but to our high character for faith and honour.

Every country has its own peculiar productions, and by an unrestrained interchange of the gifts of Providence the condition of all is improved. The exclusive jealousy with which commerce has hitherto been fettered, shows the length of time that is necessary to wear out the effects of those selfish passions which separated nations when they were yet barbarous. It required a high degree of cultivation to break down those barriers consecrated by their antiquity; and the accomplishment of this

important change evinces the rate at which the present age is advancing.

A new era in the history of the world began when China was opened to European intercourse; but many years must pass before European influence can penetrate that vast empire, and eradicate those illiberal prejudices by which it has so long been governed.

Two important triumphs yet remain to be achieved over physical difficulties by the science and energy of man, namely, the junction of the Pacific and Atlantic Oceans at the Isthmus of Central America, and the union of the Red Sea with the Mediterranean at that of Suez. The first seems to be on the eve of accomplishment, and, in conjunction with the treasures with which the auriferous district of California is said to abound, may bring about a complete revolution in the tide of affairs; and that country, hitherto so completely separated from the rest of the world and so little known, will become a new centre of civilization, whose influence will be diffused over the wide Pacific to the shores of the eastern continent; the expectation of Columbus will then be realized—of a passage to the East Indies by the Atlantic. Should the Mediterranean and Red Sea be united by a water communication, Alexandria, Venice, and the other maritime cities of southern Europe may regain, at least in part, the mercantile position which they lost by the discovery of Vasco da Gama.[1]

[1] It is singular that the British should for years have possessed such extensive territories in Asia without having explored their mineral wealth. Perhaps the quantity of gold

The advantages of colonization and commerce to the less civilized part of the world are incalculable, as well as to those at home, not only by furnishing an exchange for manufactures, important as this is, but by the immense accession of knowledge of the earth and its inhabitants, that has been thus attained.

The history of former ages exhibits nothing to be compared with the mental activity of the present. Steam, which annihilates time and space, fills mankind with schemes for advantage or defence: but however mercenary the motives for enterprise may be, it is instrumental in bringing nations together. The facility of communication is rapidly assimilating national character. Society in most of the capitals is formed on the same model; and as the study of modern languages is now considered a part of polite education, and every well-educated person speaks more than one modern tongue, one of the great barriers to the assimilation of character amongst nations will be removed.

recently discovered in California and Africa may call the attention of the East India Company to the subject. Some of the richest mining districts are in countries where primary formations have been crossed or disturbed by volcanic action; and as that is eminently the case along the eastern coast of the Bay of Bengal, from Aracan to the peninsula of Malacca, mines of the precious metals will most likely be found on that frontier, possibly in Siam and the Birman empire. The interior of the Deccan has also been greatly disturbed by ancient volcanos; and as that country is said to bear a strong analogy in structure to South Africa, it may also resemble it in the production of gold. The auriferous territory in California appears to be at least 400 miles long and 100 broad.

Science has never been so extensively and so successfully cultivated as at the present time: the collective wisdom and experience of Europe and the United States of America is now brought to bear on subjects of the highest importance in annual meetings, where the common pursuit of truth is as beneficial to the moral as to the intellectual character, and the noble objects of investigation are no longer confined to a philosophic few, but are becoming widely diffused among all ranks of society, and the most enlightened governments have given their support to measures that could not have been otherwise accomplished.[1] Simultaneous observations are

[1] In bringing to a close a work which may in some measure be considered a kind of Résumé of Natural knowledge, it may not be either out of place or irrelevant to our subject to allude more particularly to the encouragement of late years granted to scientific investigation by our own Government.

It must be confessed that Great Britain for a long time remained behind the nations of the continent in fostering scientific enterprise and research; and if England has rivalled in most branches of natural knowledge, and surpassed in some, every other people, it has arisen more from individual exertion, and that spirit of association which forms so happy a characteristic of our race, and which has in our political institutions so mainly contributed to our national greatness and prosperity, than from any direct encouragement from our rulers. Whilst France and other continental nations were endowing the votaries of science, were lavishing money on scientific expeditions, and founding institutions which will hand down the names of their sovereigns to posterity as the benefactors of mankind, England had done little in the same track beyond fitting out those memorable expeditions of Cook, and subsequently those of Vancouver and Flinders, and the

made at numerous places in both hemispheres on electricity, magnetism, on the tides and currents

support granted to our great national Observatory, which, under the direction of Bradley, Maskelyne, Pond, and Airy, has attained a degree of celebrity and utility unequalled by any astronomical foundation in ancient or modern times.

The conclusion of a long war, in opening the scientific repositories of the continent to our countrymen, showed us how much our great institutions, with the above solitary exception, were behindhand, not only in extent and utility, but in the liberality with which they were conducted. Possessing as we did the most ample means, from our immense colonial possessions and our widely extended commerce, to add to the stock of our knowledge in natural history, our collections were infinitely behind those of the great states of the continent, and scarcely on a par with those of the sovereigns of a second and even third rate importance. A better system was loudly called for, and a better system has been adopted. Our great national collection of the British Museum—and I here refer more particularly to its scientific and antiquarian department, for there is still much room for improvement in the literary—has in a few years, thanks to the liberality of Parliament and the exertions of its trustees and officers, become equal in every respect, and superior in many, to any similar institution on the continent. Two establishments have been created within the last dozen of years which reflect the greatest honour on the statesmen, Sir F. Baring, then Chancellor of the Exchequer, and the late Earl of Besborough, as chief Commissioner of the Woods and Forests, who fostered them in their infancy, and on the talented individuals who had been selected to carry out the enlightened views of the Government — the Museum of Practical Geology, a designation that conveys a very inadequate idea of the extent of its attributes or of its utility, and the Royal Botanic Gardens at Kew. To the first the public is already indebted for such a geological survey and map of the empire as never had been planned or executed in any other country—only a small instalment, however, of great services which the nation and geological science

of the air and the ocean, and those mysterious vicissitudes of temperature and moisture, which

are likely to derive from the labours of Sir H. Delabeche and his collaborators. The Royal Gardens at Kew, under the direction of Sir W. J. Hooker, lose nothing when compared with the most celebrated establishments of the kind, ancient or modern: never was public money better bestowed, or in a way to convey more useful instruction and gratification to the great mass of the community. Whilst every German university had its Museum of Comparative Anatomy, when the government of revolutionary France had placed at the disposal of Cuvier ample means to lay the basis of that science of which he was to be considered the founder, an eminent surgeon, John Hunter, animated by the love of science alone, and unaided by his Government, was rendering a similar service to Great Britain, in laying the foundation of that Museum which so justly bears his honoured name. Thanks to the liberality of the Government, and to the well-judged appreciation of the Royal College of Surgeons, the Hunterian Collection has become the property of the nation, and has received such additions and ameliorations as not to be behind any of those of the continent; whilst in point of arrangement, facilities granted for study, and real practical utility, it infinitely surpasses them all. To it we principally are indebted for the introduction of the study of comparative anatomy into this country, and for the possession of one of its greatest modern expositors, Professor Owen.

It may appear invidious, at a time when every department of our Government is showing itself so desirous of promoting the cause of science, to point to any in particular: still we cannot refrain from making special mention of one to which science in general, and more particularly that branch of it which forms the principal object of this work, and our best national interests, owe a deep and lasting debt of gratitude—the Hydrographic department of the Admiralty; which, under its present able chief, Sir Francis Beaufort, has attained a degree of eminence unequalled by that of any other maritime country. The Admiralty has profited of a long peace to

bless the labours of the husbandman one year, and blight them in another.

extend our knowledge over almost every region of the globe, conferring thereby an immense service on geographical science, and placing in the hands of our national and commercial marine a collection of charts and nautical instructions unparalleled in the history of navigation for their extent and exactitude. Another branch of inquiry, closely connected with Hydrography and Navigation, which it required the encouragement of a government to institute, the investigation of the laws of terrestrial magnetism and meteorology, has been very liberally provided for by Parliament, and most ably carried out, under the direction of Colonel Sabine, by the establishment of special observatories in our widely extended colonies, and by the publication and distribution of their results.

The several maritime expeditions undertaken since the peace in a purely scientific view reflect the highest credit on the departments of the Government with which they have originated, as they do on the eminent individuals, many of whom still live to enjoy their well-merited fame, who have carried out their country's wishes. The names of Parry, Franklin, Back, James C. Ross, and Richardson will be preserved in the memory of posterity long after the ephemeral glory of their professional career will have been forgotten.

Although it is to the projectors of such an altered state of things, and to the statesmen who encouraged and brought it about, that our first acknowledgment is due, our thanks must be also expressed to that branch of the legislature which, holding, as it rightly does, the public purse, has so liberally come forward upon every occasion, when solicited, in granting the means to promote scientific enterprise. The votary of science therefore owes to the House of Commons the expression of his unmingled gratitude.

But, in paying that just tribute to the ministers of the Crown and to Parliament, we must not pass over in silence the encouragement which science has in every department met with from the East India Company. Lords of an immense territory, the Court of Directors, and its representa-

The places of the nebulæ and fixed stars, and their motions, are known with unexampled precision, and the most refined analyses embrace the most varied objects. Three new satellites and six new planets have been discovered within four years, and one of these under circumstances the most unprecedented. In the far heavens, from disturbances in the motions of Uranus which could not be accounted for, an unknown and

tives in India, have always shown themselves ready to contribute in a most liberal spirit to the extension of our knowledge of their widely extended empire. The trigonometrical surveys of India, the establishment of observatories, the endowment of colleges and of scientific societies, the formation of collections of natural history at great expense, and which it distributes to all those who are likely to make good use of them, the publication of works on physical researches, on natural history, of astronomical observations, bestowed with so liberal a hand to men of science, the formation of such a map of its extended dominions and of charts of its coasts as would do honour to any government, must place the East India Company in the first rank of those mighty potentates of the earth to whom science will both now and in after ages feel placed under the most lasting obligations.

Connected with our Oriental empire, it is due to some of the native sovereigns of India to state that they have not been behindhand in imitating the liberal example of their powerful protectors. Two native princes, the Rajah of Travancore and the King of Oude, have at very great expense established astronomical observatories in their territories, furnished with European instruments of the most delicate construction, and placed under the direction of European officers amply endowed and provided for. The peninsula of India at the present moment possesses four astronomical observatories little behind those of Europe as regards the means of observation: until very lately there did not exist one public observatory in the whole extent of the United States of America.

unseen body was declared to be revolving on the utmost verge of the solar system; and it was found in the very region of the heavens pointed out by analysis. On earth, though hundreds of miles apart, that invisible messenger, electricity, instantaneously conveys the thoughts of the invisible spirit of man to man—results of science sublimely transcendental.

Vain would be the attempt to enumerate the improvements in machinery and mechanics, the canals and railroads that have been made, the harbours that have been improved, the land that has been drained, the bridges that have been constructed; and now, although Britain is inferior to none in many things, and superior to all in some, one of our most distinguished engineers declares that we are scarcely beyond the threshold in improvement; to stand still is to retrograde, human ingenuity will always keep pace with the unforeseen, the increasing wants of the age.[1] "Who knows what may yet be in store for our use; what new discovery may again change the tide of human affairs; what hidden treasures may yet be brought to light in the air or in the ocean, of which we know so little; or what virtues there may be in the herbs of the field, and in the treasures of the earth—how far its hidden fires, or stores of ice, may yet become available—ages can never exhaust the treasures of nature or the talent of man."[2] It would be difficult to follow the rapid course of discovery through the complicated mazes of magnetism and electricity; the action of the electric current on the

[1] Sir John Rennie. [2] Charles Babbage, Esq.

polarized sun-beam, one of the most beautiful of modern discoveries, leading to relations hitherto unsuspected between that power and the complex assemblage of visible and invisible influences on solar light, by one of which nature has recently been made to paint her own likeness. It is impossible to convey an idea of the rapid succession of the varied and curious results of chemistry, and its application to physiology and agriculture; moreover, distinguished works have lately been published at home and abroad on the science of mind, which has been so successfully cultivated in our own country. Geography has assumed a new character, by that unwearied search for accurate knowledge and truth that marks the present age, and physical geography is altogether a new science.

The spirit of nautical and geographical discovery, begun in the 15th century, by those illustrious navigators who had a new world to discover, is at this day as energetic as ever, though the results are less brilliant. Neither the long gloomy night of a polar winter nor the dangers of the ice and the storm deter our gallant seamen from seeking a better acquaintance with "this ball of earth," even under its most frowning aspect; and that, for honour, which they are as eager to seek even in the cannon's mouth. Nor have other nations of Europe and America been without their share in these bold adventures. The scorching sun and deadly swamps of the tropics as little prevent the traveller from collecting the animals and plants of the present creation, or the geologist from investigating those of ages long gone by. Man

daily indicates his birthright as lord of the creation, and compels every land and sea to contribute to his knowledge.

The most distinguished modern travellers, following the noble example of Baron Humboldt, the patriarch of physical geography, take a more extended view of the subject than the earth and its animal and vegetable inhabitants afford, and include in their researches the past and present condition of man, the origin, manners, and languages of existing nations, and the monuments of those that have been. Geography has had its dark ages, during which the situation of many great cities and spots of celebrity in sacred and profane history had been entirely lost sight of, which are now discovered by the learning and assiduity of the modern traveller. Of this, Italy, Egypt, the Holy Land, Asia Minor, Arabia, and the valleys of the Euphrates and Tigris, with the adjacent mountains of Persia, are remarkable instances, not to mention the vast region of the East, and the remote centres of aboriginal civilization in the New World. The interesting discoveries of Mr. Layard, who possessed every acquirement that could render a traveller competent to accomplish so arduous an undertaking, have brought to light the long-hidden treasures of the ancient Nineveh, where its own peculiar style of art had existed anterior to that of Egypt.[1] In many

[1] We learn, on closing the present volume, that this distinguished traveller, through the liberality of Her Majesty's Government, is again about to proceed to the former field of his exertions.

parts of the world the ruins of cities of extraordinary magnitude and architecture show that there are wide regions of whose original inhabitants we know nothing. The Andes of Peru and Mexico have remains of civilized nations before the age of the Incas. Mr. Pentland has found numerous remains of Peruvian monuments in every part of the great valley of the Peru-Bolivian Andes, and many parts of the imperial capital Cusco little changed from what they were at the downfall of Atahualpa. Mr. Stephens has found in the woods of Central America the ruins of great cities, adorned with sculpture and pictorial writings, vestiges of a people far advanced, who had once cultivated the soil where these entangled forests now grow. Picture-writings have been discovered by Sir Robert Schomburgk on rocks in Guiana, spread over an extent of 350,000 square miles, similar to those found in the United States and in Siberia. Magnificent buildings still exist in good preservation all over eastern Asia, and many in a ruinous state belong to a period far beyond written record.

Ancient literature has furnished a subject of still more interesting research, from which it is evident that the mind of man is essentially the same under very different circumstances: every nation far advanced in civilization has had its age of poetry, the drama, romance, and philosophy, each stamped with the character of the people and times, and still more with their religious belief. Our profound Oriental scholars have made known to Europeans the refined

Sanscrit literature of Hindostan, its schools of philosophy and astronomy, its dramatic writings and poetry, which are original and beautiful, and to these the learned in Greece and Italy have contributed.

The riches of Chinese literature and their valuable geography were introduced into Europe by the French Jesuits of the last century, and followed up with success by the French and English philosophers of the present: to France we also owe much of our knowledge of the poetry and letters of Persia; and from the time that Dr. Young deciphered the inscriptions on the Rosetta Stone, Egyptian hieroglyphics and picture-writing have been studied by the learned of France, England, and Italy, and we have reason to expect much new information from the more recent researches of Professor Lepsius of Berlin. The Germans, indeed, have left few subjects of ancient literature unexplored, even to the language written at Babylon and Nineveh—the most successful attempt to decipher which is due to a distinguished countryman of our own, Colonel Rawlinson.

The press has overflowed with an unprecedented quantity of literature, some of standard merit, and much more that is ephemeral, suited to all ranks, on every subject, with the aim, in our own. country at least, to improve the people, and to advocate the cause of morality and virtue. All this mental energy is but an effect of those laws which regulate human affairs, and include in their generality the various changes that tend to improve the condition of man.

The fine arts do not keep pace with science, though

they have not been altogether left behind. Painting, like poetry, must come spontaneously, because a feeling for it depends upon innate sympathies in the human breast. Nothing external could affect us, unless there were corresponding ideas within; poetically constituted minds of the highest organization are most deeply impressed with whatever is excellent. All are not gifted with a strong perception of the beautiful, in the same way as some persons cannot see certain colours, or hear certain sounds. Those elevated sentiments which constitute genius are given to few; yet something akin, though inferior in degree, exists in most men. Consequently, though culture may not inspire genius, it cherishes and calls forth the natural perception of what is good and beautiful, and by that means improves the tone of the national mind, and forms a counterpoise to the all-absorbing useful and commercial.

Historical painting is successfully cultivated both in France and Germany. The Germans have modelled their school on the true style of the ancient masters. They have become their rivals in richness and beauty of colouring, and are not surpassed in vividness of imagination, nor in variety and sublimity of composition, which is poetry of the highest order embodied. Sculpture and architecture are also marked by that elevated and pure taste which distinguish their other works of art.[1] French artists,

[1] The works of Cornelius and Kaulbach bear testimony to the justice of the observations in the text. In drawing, nothing can be more beautiful—in composition, nothing can be

following in the same steps, have produced historical works of great merit. Pictures of *genre* and scenes of domestic life have been painted with much expression and beauty by our own artists; and British landscapes, like some painted by German artists, are not mere portraits of nature, but pictures of high poetical feeling, and the excellence of their composition has been acknowledged all over Europe, by the popularity of the engravings which illustrate many of our modern books. The encouragement given to this branch of art at home may be ascribed to the taste for a country life so general in England. Water-colour painting, which is entirely of British growth, has now become a favourite style in every country, and is brought to the highest perfection in our own.

The Italians have had the merit of restoring sculpture to the pure style which it had lost, and that gifted people have produced some of the noblest specimens of modern art. The greatest genius of his time left the snows of the far North to spend his days in Rome, the head-quarters of art; and our own sculptors of eminent talents have established themselves in Rome, where they find a more congenial spirit than in their own country, in which the compositions of Flaxman were not appreciated till

more varied or sublime. The 'Destruction of Jerusalem,' by Kaulbach, in which a powerful genius has combined the truth of the historian with the imagination of the poet, and executed with the hand of a master, might bear comparison even with the Italian school for colouring.

they had become the admiration of Europe. Munich can boast of some of the finest specimens of modern sculpture and architecture.

The Opera, one of the most refined of theatrical amusements in every capital city in Europe, displays the excellence and power of Italian melody, which has been transmitted from age to age by a succession of great composers. German music, partaking of the learned character of the nation, is rich in original harmony, which requires a cultivated taste to understand and appreciate.

Italy is the only country that has had two poetical eras of the highest order; and, great as the Latin period was, that of Dante was more original and sublime. The Germans, so eminent in every branch of literature, have also been great as poets; the power of Goethe's genius will render his poems as permanent as the language in which they are written. France is, as it long has been, the abode of the Comic Muse; and although that nation can claim great poets of a more serious cast, yet the language and the habits of the people are more suited to the gay than the grave style. Though the British may have been inferior to other nations in some branches of the fine arts, yet poetry, immeasurably the greatest and most noble, redeems, and more than redeems us. The nation that produced the poetry of Chaucer, Spenser, Shakespeare and Milton, with all the brilliant train, down nearly to the present time, must ever hold a distinguished place, as an imaginative people. Shakespeare alone would stamp a language with im-

mortality. The British novels stand high among works of imagination, and they have generally had the merit of advancing the cause of morality. Had French novelists attended more to this, their knowledge of the human heart and the brilliancy of their composition would have been more appreciated.

Poetry of the highest stamp has fled before the utilitarian spirit of the age; yet there is as much talent in the world, and imagination too, at the present time, as at any former period, though directed to different and more important objects, because the whole aspect of the moral world is altered. The period is come for one of those important changes in the minds of men which occur from time to time, and form great epochs in the history of the human race. The whole of civilized Europe could not have been roused to the enthusiasm which led them to embark in the Crusades by the preaching of Peter the Hermit, unless the people had been prepared for it: men were ready for the Reformation before the impulse was given by Luther; and Pius IX. merely applied the match to a train already laid. These are the barometric storms of the human mind.

The present state of transition has been imperceptibly in progress, aided by many concurring circumstances, among which the increasing intelligence of the lower orders, and steam-travelling, have been the most efficient. The latter has assisted eminently in the diffusion of knowledge, and has probably accelerated the crisis of public affairs on the Continent,

by giving the inhabitants of different countries opportunities of intercourse, and comparing their conditions. No invention that has been made for ages has so levelling a tendency, which accords but too well with the present disposition of the people. The spirit of emancipation, so peculiarly characteristic of this century, appears in all the relations of life, political and social. On the continent of Europe it has shaken the whole fabric of society, subverted law and order, and ruined thousands, in order to throw down the crumbling remains of the feudal system. The same emancipating spirit which has thrown young and old into a state of insubordination and rebellion abroad, has been quietly but gradually altering the relations of social and domestic life at home. Parent and child no longer stand in the same relation to one another; even at an early age boys assume the character and independence of men, which may perhaps fit them sooner for taking their share in the affairs of the world; for it must be acknowledged that, whether from early independence or some other cause, no country has produced more youthful and able statesmen than our own; but, at the same time, it places them on a less amicable and more dangerous position, by depriving them of the advice and experience of the aged, to which the same deference is no longer paid. The working man considers his interest to be at variance with that of the manufacturer, and the attachment of servants to their masters is nearly as extinct in Britain as vassalage. Ambition, to a great extent, pervades the inferior and

middle grades of society, and so few are satisfied with the condition in which they were born, that the pressure upwards is enormous. The numerous instances of men rising from an inferior rank to the highest offices in the State encourages the endeavour to rise in society, which is right and natural, if pursued by legitimate means, but the levelling disposition so prevalent abroad is pernicious as it is impracticable. So long as men are endowed with different dispositions and different talents, so long will they differ in condition and fortune, and this is as strongly marked in republics as in any other form of government; for man, with all his attempts to liberate himself from nature's ordinances, by the establishment of equal laws and civil rights, never can escape from them—inequality of condition is permanent as the human race. Hence from necessity we must fulfil the duties of the station in which we are placed, bearing in mind that, while Christianity requires the poor to endure their lot with patience, it imposes a heavy responsibility on the rich.

In Britain, respect for the labouring classes, together with active benevolence, form the counterpoise to the evil propensities of this state of transition; a benevolence which is not confined to alms-giving, but which consists in the earnest desire to contribute with energy to the sum of human happiness. In proportion as that disposition is diffused among the higher classes, and the more they can convince the lower orders that they have an ardent desire to afford them every source of happiness and comfort that is

in their power, so much sooner will the transient evils pass away, and an improved state of things will commence; kindly and confiding feelings will then take the place of coldness and mistrust.

The continual increase of that disinterested benevolence and liberal sentiment, which in our own country is the most hopeful and consoling feature of the age, manifests itself in the frequency with which plans for ameliorating the condition of the lower classes are brought before Parliament; in the societies formed for their relief; and in the many institutions established for their benefit and comfort.

Three of the most beneficial systems of modern times are due to the benevolence of English ladies—the improvement of prison discipline, savings-banks, and banks for lending small sums to the poor. The success of all has exceeded every expectation, and these admirable institutions are now adopted by several foreign countries. The importance of popular and agricultural education is becoming an object of attention to the more enlightened governments; and one of the greatest improvements in education is, that teachers are now fitted for their duties, by being taught the art of teaching. The gentleness with which instruction is conveyed no longer blights the joyous days of youth, but, on the contrary, encourages self-education, which is the most efficient.

The system of infant-schools, established in many parts of Europe and throughout the United States of America, is rapidly improving the condition of the people. The instruction given in them is suited to the

station of the scholars, and the moral lessons taught are often reflected back on the uneducated parents by their children. Moreover, the personal intercourse with the higher orders, and the kindness which the children receive from them, strengthen the bond of reciprocal good feeling. Since the abolition of the feudal system, the separation between the higher and the lower classes of society has been increasing; but the generous exertions of individuals, whose only object is to do good, is now beginning to correct a tendency that, unchecked, might have led to the worst consequences to all ranks. We learn from statistical reports that the pains taken by individuals and associations are not without their effect upon the character of the nation. For example, during the eleven years that preceded 1846, in which the criminal returns indicated the intellectual condition of persons accused, there were 31 counties in England and Wales in which not one educated woman was called before a court of law, in a population of 2,617,653 females.[1]

[1] Twenty of these counties were in England and 11 in Wales, and so few crimes took place among educated women in the other counties during the 11 years mentioned, that the annual proportion of accusations against educated females was only 1 in 1,349,059. During the year 1846 only 48 educated persons were convicted of crimes out of the whole population of England and Wales, and none were sentenced to death. And during the years 1845 and 1846 there were 15 counties in England and 11 in Wales in which no well-educated person was convicted of any crime. The number of accusations among educated persons in Scotland is greater, because education is more general, and because the quantity of ardent

Crime has generally decreased in proportion to the religious and moral education of the people: the improvement in the morality of the factory-children is immense since Government appointed inspectors to superintend their health and education;[1] and indeed the improvement in the condition of the whole population appears from the bills of mortality, which unquestionably prove that the duration of human life is continually increasing throughout Great Britain.[2]

The voluntary sacrifices that have been made to relieve the necessities of a famishing nation evince

spirits used in Scotland is five times greater than in England. Crime is very much below the average in the mining districts, and it is still less frequent in Wales and in the mountainous country in the North of England. The accomplishments of a *well*-educated person in these statistical records consist merely in being able to read and write fluently.—'London Statistical Journal.'

[1] Every factory-child is limited to 48 hours of labour in the week, and the children must by law attend school at least two hours a-day for six days out of the seven, besides a Sunday-school—one penny being deducted out of each shilling of wages for education. The inspectors have the power of establishing schools where wanted, and of dismissing incompetent teachers. The engagement of factory-children in Britain lasts till they are 13, in the United States it ends at 15 years of age.—'Statistical Journal.'

[2] The average duration of the life of sovereigns is greater in modern than in ancient times, but it is still lower than any other class of mankind. The most favourable average for them is 70·05 years; for the English aristocracy it is 71·69; for the English gentry, 74·00; for the learned professions, 73·62; for English literary and scientific men it is 72·10; for the army and navy, 71·99; and for the professions of the fine arts, 71·15.—'London Statistical Journal.'

the humane disposition of the age. But it is not one particular and extraordinary case, however admirable, that marks the general progress—it is not in the earthquake or the storm, but in the still small voice of consolation heard in the cabin of the wretched, that is the prominent feature of the charities of the present time, when the benevolent of all ranks seek for distress in the abodes of poverty and vice, to aid and to reform. No language can do justice to the merit of those who devote themselves to the reformation of the children who have hitherto wandered neglected in the streets of great cities; in the unpromising task they have laboured with patience, undismayed by difficulties that might have discouraged the most determined—but they have had their reward, they have succeeded.[1] The language of kindness and sympathy, never before heard by these children of crime and wretchedness, is saving multitudes from perdition. But it would require a volume to enumerate the exertions that are making for the accommodation, health, and improvement of the people, and the devotion of high and low to the introduction of new establishments and the amelioration of the old. Noble and liberal sentiments mark the proceedings of public assemblies, whether in the cause of nations or of individuals, and the severity of our penal laws is mitigated by a milder system. Happily this liberal and benevolent spirit is not confined to

[1] There are 62 Ragged Schools in London, and Government undertakes to send annually to the colonies 150 of such of the scholars as choose to go.—'London Statistical Journal.'

Britain, it is universal in the States of the American Union, and it is spreading widely through the more civilized countries of Europe.

No retrograde movement can now take place in civilization; the diffusion of Christian virtues and of knowledge ensures the progressive advancement of man in those high moral and intellectual qualities that constitute his true dignity. But much yet remains to be done at home, especially in religious instruction and the prevention of crime; and millions of our fellow-creatures in both hemispheres are still in the lowest grade of barbarism. Ages and ages must pass away before they can be civilized; but if there be any analogy between the period of man's duration on earth and that of the frailest plant or shell-fish of the geological periods, he must still be in his infancy; and let those who doubt of his indefinite improvement compare the first revolution in France with the last, or the state of Europe in the middle ages with what it is at present. For, notwithstanding the disturbed condition of the Continent and the mistaken means the people employ to improve their position, crime is less frequent and less atrocious than it was in former times, and the universal indignation it now raises is a strong indication of improvement. In our own country, men who seem to have lived before their time were formerly prosecuted and punished for opinions which are now sanctioned by the legislature, and acknowledged by all. The moral disposition of the age appears in the refinement of conversation. Selfishness and evil passions may pos-

sibly ever be found in the human breast, but the progress of the race will consist in the increasing power of public opinion, the collective voice of mankind regulated by the Christian principles of morality and justice. The individuality of man modifies his opinions and belief; it is a part of that variety which is a universal law of nature; so that there will probably always be a difference of views as to religious doctrine, which, however, will become more spiritual, and freer from the taint of human infirmity; but the power of the Christian religion will appear in purer conduct, and in the more general practice of mutual forbearance, charity, and love.

APPENDIX.

TABLE of the Heights above the Sea of some of the Principal Mountain Chains.

EUROPE.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
MONT BLANC	15,739	Alps, P[1]	P. S.[2]
Monte Rosa	15,210	,, L.	,,
Mont Cervin	14,836	,, P.	,,
Finsterärhorn	14,026	,, B.	Eichman.
Jungfrau	13,672	,, B.	,,
Le Géant du M. Blanc . .	13,786	,, P.	P. S.
Mont Combin	14,124	,, P.	,,
Mont Iséran	13,272	,, G.	,,
Monte Viso	13,599	,, C.	,,
Ortler Spitz	12,851	,, R.	A. S.
Le Grand Rioburent . . .	11,063	,, M.	P. S.
Drey Herrn Spitz . . .	10,122	,, Car.	A. S.
Mont Terglou	9,386	,, J.	,,
Passes of the Alps:—			
Col du Géant	11,238[3]	,, P.	Saussure.
Col de St. Theodule . . .	11,185	,, P.	P. S.
Pass of Great St. Bernard .	8,173	,, P.	,,
,, La Furka . . .	8,714	,, L.	S. S.
,, Mont Moro . . .	8,937	,, L.	P. S.
,, Le Tavernette . .	9,827	,, C.	,,

[1] The letters affixed indicate the parts of the Alps to which each locality belongs— M., Maritime; C., Cottian; G., Grecian; P., Pennine; L., Lepontine; B., Bernese, or Helvetian; R., Rhetian; J., Julian; Car., Carniac.

[2] The authorities on which these heights are given are—the Piedmontese Surveys (P. S.), as published in 1845, in the Work entitled 'Le Alpi che cingono l'Italia,' 1 vol. 8vo.; the Austrian Survey (A. S.), as given in the splendid Maps, published by the Austrian Government, of the Regno Lombardo-Veneto, in 84 sheets; and the Swiss Trigonometrical Survey, by Eichman, 1 vol. 4to., 1846.

[3] The first eight passes are only fit for foot-passengers, and in certain seasons for mules: the remaining eleven offer carriage-roads, and are generally open at all seasons of the year, with the exception of the Stelvio.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Pass of Mont Iséran . . .	9,196	Alps, G.	P. S.
„ Col des Fénêtres .	9,581	„ P.	„
the Stelvio . . .	9,177	„ R.	A. S.
„ Bernardino . . .	7,015	„ R.	„
„ the Splugen . . .	6,946	„ R.	„
„ St. Gothard . . .	6,808	„ R.	S. S.
„ Mont Cenis . . .	6,772	„ G.	P. S.
„ Simplon	6,578	„ L.	„
„ Tende	6,159	„ M.	„
„ Mont Genèvre . . .	6,119	„ C.	P. S.
„ Brenner	4,659	„ R.	A. S.
„ Pontebba . . .	3,625	„ J.	A. S.
Malahite Peak	11,168	Pyrenees	A. B. L.[1]
Mont Perdu Peak . . .	10,994	„	„
Maboré, Cylinder of . . .	10,899	„	„
Maladetta „	10,886	„	„
Vignemale „	10,820	„	„
Pic du Midi	9,540	„	„
Canigou	9,137	„	„
Passes of the Pyrenees:—			
Pass or Port d'Oo . . .	9,843	„	„
„ d'Estaube . .	8,402	„	„
„ de Gavarnie .	7,654	„	„
„ de Tourmalet .	7,143	„	„
Pic de Sancy	6,188	France	„
Plomb du Cantal	6,093	„	„
Mont Mezen	5,795	„	„
Puy de Dôme	4,806	„	„
Ballon des Vosges	4,688	„	„
Mont Ventoux	6,263	„	„
Mulahaçen	11,483	Spain	„
Sierra de Gredos	10,552	„	Bory.
Estrella	7,526	„	Franzini.
Siete Picos	7,244	„	Bauza.
Peña Laza	8,222	„	„
El Gador	6,575	„	Rojas.
Monte Corno, or Gran Sasso d'Italia	9,521	Italy, Apennines	

[1] Heights taken from the list published in the French 'Annuaire du Bureau des Longitudes,' converted from metres into English feet.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Monte Vellino	7,851	Italy, Apennines	M. de Prony.
Termenillo Grande	7,212	,,	Schow.
Monte Amaro di Majella .	9,113	,,	,,
Monte Cimone	6,975	,,	,,
Mont Amiata	5,794	Tuscany	,,
St. Oreste or Soracte . .	2,140	Campagna of Rome.	,,
Passes of the Apennines:—			
Pass of Noviordi Giovi . .	1,550	. .	,,
,, La Bochetta . . .	2,550	. .	,,
,, Pietramala . . .	3,294	. .	,,
Islands of the Mediterranean:—			
Monte Rotondo	8,767	Corsica	A. B. L.
,, d'Oro	8,701	,,	,,
,, Generargenta . .	6,004	Sardinia	La Marmora.
Mount Etna	10,874	Sicily	W.H.Smyth.
Pizzo di Cane	6,509	,,	A. B. L.
Mount Eryx	3,894	,,	,,
Stromboli	2,687	Lipari Isles	De Borch.
Greece and Morea:—			
Mount Guiona	8,538	. .	Peytier.[1]
Parnassus	8,068	. .	,,
Taygetus, Mont St. Elias .	7,904	. .	,,
Mont Olonas	7,293	. .	,,
,, Kelmos	7,726	. .	,,
,, Athos	6,778	. .	De Borch.
,, Helicon	5,738	. .	Peytier.
Delphi	5,725	. .	,,
Mont Hymettus	3,378	. .	,,
Central Europe:—			
Ruska Joyana	9,912	E. Carpaths.	Malte Brun.
Budosch, Transylvania . .	9,593	,,	A. B. L.
Surrul	9,593		
Mount Tatra, highest point .	8,524	W. Carpaths.	Wahlenberg.
,, Csabi Peak .	8,314	,,	,,
,, Lomnitz . .	8,861	,,	A. B. L.

[1] Heights determined by the French expedition under Captains Peytier and Boblaye, and published in the 'Connaissance des Temps' for 1839.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Riesenkoppe, in the Riesengeberge	5,394	Germany	Horen.
Feldberg, in the Schwarzwald	4,675	,,	French Engineers.
Belchenberg ,, ,,	4,642	,,	,,
Kandelberg ,, ,,	4,160	,,	Bohnenberger.
Schneeberg, Geisengebirge .	4,784	,,	
Kammkoppel ,, ,,	4,265	,,	Charpentier.
Sonnenwerbel, in the Erzgebirge	4,124	,,	
Rachelberg, in the Böhmerwald	4,561	,,	Sternberg.
Steinberg, Moravia . . .	3,511	,,	David.
Brocken, Hartz	3,658	,,	Zach.
Schneeberg, in the Fichtelgebirge	3,461	,,	Goldfuss.
Blessberg, in the Thuringerwald	2,748	,,	Zach.
Glockner ,, ,,	2,231	,,	,,
Gross Feldberg, in the Taunus chain	2,775	,,	Schmidt.
Lowenberg, in the Siebengebirge	2,024	,,	Nose.
Norway and Sweden:—			
Skagtöltend . Lat. 61° 24′	8,101	Scandinavian Mountains	Keilhau.
Koldetind	7,224	,,	,,
Sognefield	7,182	,,	Hagelstam.
Mugnafield . Lat. 61° 20′	7,215	,,	Forsell.
Schneehattan . ,, 62 20	8,120	,,	Eismark.
Pighœttan . . ,, 62 2	6,788	,,	Hagelstam.
Sulitelma . . ,, 67 5	6,178	,,	Wahlenberg.
Langfield . . ,, 61 53	6,598	,,	Hagelstam.
Melderskin . ,, 60 0	4,859	,,	Von Buch.
Lyngen Mountains 69 30	4,300	,,	,,
Great Britain:—			
Ben Nevis.	4,380	Scotland .	Jameson.
Cairntoul, Aberdeenshire .	4,223	,,	Playfair.
Ben Avon ,, .	3,931	,,	,,

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Ben More, Grampians . .	3,819	Scotland	Playfair
Schehallien ,, . .	3,514	,,	,,
Snowdon	3,557	Wales	Roy.
Cader Idris	3,550	,,	,,
Carn Llewellyn	3,471	,,	,,
Cross Fell, Cumberland . .	3,383	England	Jameson.
Helvyllen, ,, . .	3,313	,,	,,
Skiddaw, ,, . .	3,038	,,	Dr. Young.
Schunner Fell, Yorkshire .	2,388	,,	Smith.
Coniston Fell, Lancashire .	2,575	,,	,,
Cheviot Hills	2,657	,,	,,
Pentland Hills	1,878	Scotland	Playfair.
Curran Tual, Kerry . . .	3,412	Ireland	Nimmo.
Sleib Donnard	3,146	,,	,,
Nephin, Mayo	2,644	,,	Jameson.
Mourne Mountains, Down .	2,493	,,	,,
Ben More, Isle of Mull . .	3,100	Hebrides	,,
Hecla, Isle of S. Uist . .	3,002	,,	Boué.
Cuchullin, Isle of Skye . .	2,995	,,	M'Culloch.
Mount Rona	3,593	Shetland	Laing.
Iceland and Feroe:—			
Snœfials, Jokull	5,115	Iceland	A. B. L.
Hecla	3,324	,,	,,
Skalingefield, Isle Stromoe .	2,172	Feroe	Stein.

ASIA.

Himalaya Chain:—			
Kunchinginga, W. part . .	28,178	Sikim	Col. Waugh.[1]
,, E. Peak . .	27,826	,,	,,
Dwalagiri	26,862	Nepaul	Webb.
Juwahir	25,670	Kumaöon	Herbert.
Jumoo	25,312	Sikim	Waugh.
Jumnautri	25,500	Nepaul	Webb.
Dhaibun	24,740	,,	,,
Kabroo	24,005	Sikim	Waugh.
Chamalari	23,929	Tibet	,,
Powhunry	23,176	Sikim	,, [1]

[1] The heights in the Sikim Himalaya are the results of the observations of Colonel Waugh, Director of the Trigonometrical Survey of India. *See* 'Journal of As. Soc. of Bengal,' Nov. 1848.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Momonangli, or Gurla	23,500	Tibet	Strachey.[1]
Api Peak	22,799	Nepaul	Webb.
Peak No. 12	23,263	Between the Kali and E. branch of the Ganges.	,,
,, 13	22,313		,,
,, 23	22,727		,,
,, 25	22,277		,,
St. George's Peak	22,500	Between the Ganges and Sutlej.	,,
St. Patrick's Peak	22,638		,,
Gungoutri Pyramid	21,219		,,
Jownlee Peak (highest)	21,940	Kumaöon	,,
Kailas Peak	21,000	Tibet	Strachey.
Kohibaba	17,905	Hindoo Cush	Burnes.
Peak N. of Cabul	20,232	,,	,,
Passes of the Himalaya :—			
Karokorum Pass	18,600	Tibet	Dr. Thomson.[2]
Parangla Pass	18,500	,,	Cunningham.
Kronbrung Pass	18,313	,,	Gerard.
Langpya Dhura or Doora Ghaut	17,750	,,	Strachey.
Lipu Lek Pass	16,884	,,	Manson.
Niti Ghaut Pass	16,814	,,	Gerard.
Paralaha Pass	16,500	,,	Webb.
Shatool Pass	15,500	,,	,,
Elbrouz	18,493	Caucasus	Fuss.
Kasbeck	16,530	,,	A. C.[3]
Demavend	14,695	Persia	Thomson.
Ararat	17,112	,,	Parrot.
Argæus	13,197	Asia Minor	A. C.
Beloukha	11,062	Altai	,,
Mount Lebanus	9,517	Syria	A. B. L.
,, Horeb	8,593	,,	Rüppell.
,, Sinai	7,498	,,	,,
Jebel Serbal	6,760	,,	,,
Kamen Peak	5,397	Ural	A. C.
Tremel Peak	5,071	,,	,,

[1] For Lieut. Strachey's observations during his very interesting journey to the Sacred Lakes of Manasarowar, &c., *see* 'Journal of As. Soc. of Bengal,' Aug. 1848.

[2] *See* Hooker's 'Journal of Botany,' May, 1849.

[3] The heights followed by the letters A. C. have been taken from Humboldt's 'Asie Centrale.'

AFRICA, AND ISLANDS IN THE ATLANTIC.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Mount Atlas (Miltsin) . .	11,400	Morocco	Washington.
,, Abba Jarrat 13° 10′N	15,008	Abyssinia	Rüppell.
,, Buahat . 13 12 N	14,362	,,	,,
Kilimandjaro . 4 0 S (doubtful.)	20,000	,, in the Mtns. of the Moon.	Ans. of Phil.
Table Mountain	3,816	Cape of Good Hope.	A. B. L.
Pico Ruivo	6,056	Madeira	Vidal.
Peak of Teyde, Teneriffe .	12,172	Canaries.	Von Buch.
Chahorra, Teneriffe . . .	9,885	,,	,,
Pico de Cruz, Palma. . .	7,730	,,	Vidal.[1]
Los Pexos, Great Canary .	6,400	,,	,,
Alto Garaona, Gomera . .	4,400	,,	,,
San Anton, Ferro . . .	3,907	,,	,,
Asses' Ears, Fuestaventura .	2,770	Canaries.	,,
Peak of Fogo	9,154	Cape Verde Islands.	Deville.
Pico, Island of San Antonio .	8,815	,,	Capt. King.
Pico, Island of Pico . . .	7,613	Azores	Vidal.
Pico de Vara, Island of St. Michael's	3,570	,,	,,
Caldeira de Sta. Barbara, Terceira	3,500	,,	,,
Pico de San Jorje . . .	3,498	,,	,,
Morro Gordo, Flores. . .	3,087	,,	,,
Caldeira de Corvo . . .	2,460	,,	,,

AMERICA.

North America:—			
Mount St. Elias	16,775	N. America	A. B. L.
Popocatepetl	17,717	Mexico	,,
Orizaba	17,374	,,	Humboldt.

[1] The heights given on Captain Vidal's authority are taken from the elaborate Admiralty Surveys of Madeira, the Canaries, and Azores, partly executed under his direction; the latter not yet published.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Iztacihuatl	15,705	Mexico	Humboldt.
Nevado of Toluca . . .	15,542	,,	A. B. L.
Sierra Nevada	15,170	,,	Humboldt.
Perote Mount	13,413	,,	,,
Fair Weather Mountain . .	14,925	N. America	
Jorullo	4,265	Mexico	,,
Volcan de Fuego, west peak	13,160	Guatemala	Basil Hall.
,, ,, east peak	13,050	,,	,,
Irasu, or Volcano of Cartago	11,480	,,	Phys. Atlas.
West Indies:—			
Blue Mountains	7,277	Jamaica	
La Souffrière	5,108	Guadaloupe	
Montagne Pelée	4,432	Martinique	Monnier.
Mount Garon	4,370	St. Vincent's	Chisholm.
South America:—			
La Silla de Caraccas . . .	8,600	Venezuela	Humboldt.
Cerro de Duida	8,280	,,	,,
Roraima . Lat. 5° 30′ N.	7,450	Guiana	Schomburgk.
Mountains of Santa Martha .	19,000?	New Grenada	
Plain of Bogota	8,730	,,	Humboldt.
Volcano of Tolima . . .	18,020	Andes of N. Grenada	,,
Volcano of Purace . . .	17,034		,,
Cumbal	15,620	,,	Bousingault.
Cayambe	19,535	Andes of the	Humboldt.
Antisana	19,137	Equator	,,
Cotopaxi	18,875	,,	,,
Pichincha	15,924	,,	,,
Chimborazo	21,424	,,	,,
Illinissa	17,380	,,	Bouguer.
Tunguragua	16,424	,,	Humboldt.
Sangai	16,138	,,	La Condamine.
Vilcañota Mount	17,525	Peru	Pentland.[1]
Apu-Cunuranu	17,590	,,	,,
Guaracoota Peak, Snowline .	16,297	,,	

[1] [illegible]he heights given in this table on Mr. Pentland's authority have been taken from [illegible] of 'The Laguna of Titicaca, and of the Valleys of Yucay, Collao, and [illegible]o,' published in 1848.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Cololo . . . Lat. 14° 58′	17,930	Bolivia	
Volcano of Arequipa . .	20,320	Peru	Pentland.
Quenuta . . Lat. 17° 41′	18,765		,,
Chipicani	19,745	,,	,,
Pomarape	21,700	,,	,,
Parinacota	22,030	,,	,,
Sahama	22,350	,,	,,
Gualateiri . Lat. 18° 23′	21,960	,,	,,
Ancohuma, S. Peak . . .	21,286	Bolivian Andes	,,
,, N. Peak . . .	21,043	,,	,,
Chachacomani, N. Peak . .	20,355	,,	,,
Angel Peak . Lat. 16° 10′	20,115	,,	,,
Supaïwasi, or Huayna Potosi	20,260	,,	,,
Cacaca . . Lat. 16° 25′	18,210	,,	,,
La Mesada, S. Peak . . .	19,356	,,	,,
Illimani, S. Peak	21,140	,,	,,
Mount de las Litanias . .	14,500	,,	,,
,, Miriquiri Peak Lat. 17°	16,100	,,	,,
Cerro, or Mountain of Potosi	16,152	,,	,,
,, of Chorolque, near Tupisa	16,550	,,	Redhead.
Aconcagua Mountain . .	23,910	Chile[1]	Fitzroy and Beechey
Tupungato	15,000	,,	
Antuco	16,000	,,	Fitzroy
Villarica	16,000	,,	,,
Volcano of Osorno, or Llanquihue	7,550	,,	,,
Yanteles	8,030	,,	,,
Minchinmadava Volcano .	8,000	,,	,,

[1] As stated in the text, vol. i. p. 155. The height here assigned to the Peak of Aconcagua differs 700 feet from that given by Captain Fitzroy. A re-calculation, however, of his elements has led us to adopt a much greater elevation for the giant of the Chilian Andes than given by that talented officer.

Captain Fitzroy's observations place the summit of the Peak of Aconcagua, which on his chart is incorrectly designated as a volcano, in lat. 32° 38′ 30″, long. 70° 00′ 30″ W., or 23′ 23″ N., and 100′ 45″ E. of Valparaiso, or its nearest distance about $88\frac{9}{10}$ geographical miles. From a station near Captain Fitzroy's, at Valparaiso, Captain Beechey found the angle of elevation of Aconcagua, by several very careful observations, to be 1° 55′ 45″, the distance from this station to the Peak being 88·74 geographical miles. From a discussion of all these data, the compiler of this table has deduced for the height of Aconcagua 23·910 feet above the sea.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Mount Stokes.	6,400	Patagonia	Fitzroy.
Mount Burney	5,800	,,	,,
Mount Sarmiento . . .	6,900	Tierra del Fuego	,,
Mount Darwin	6,800	,,	,,
Passes of the Andes:			
Rumihuasi	16,160	Peru	Gaye.
Altos de Toledo	15,790	,,	Pentland.
Pacuani	15,340	Bolivia	,,
Chullunquiani	15,160	,,	,,
Vilcañota, or la Raya. . .	14,520	Peru	,,
Gualillas	14,750	,,	,,
Paramo d'Assüay	15,528	Equator	Humboldt.
Guanacas	14,708	,,	Bouguer.
Pass of Quindiu	11,502	N. Grenada	Humboldt.
,, el Almorsadero . .	12,850	,,	,,
,, La Cumbre	12,450	Chile	Pentland.
,, Peuquenes	13,210	,,	Dr. Gillies.
,, el Portillo	14,365	,,	,,
Mountains of Brazil:			
Itambe	5,960		Eschwege.
Villarica chain, Serra da Piedade.	5,830		,,
Itacolumi	5,750		,,

ISLANDS IN THE PACIFIC, POLYNESIA, AUSTRALASIA, &c.

Isle of Bourbon, highest point	8,340	. .	Phys. Atlas.
Mount Ambotismene. . . .	11,506	Madagascar	A. B. L.
Adam's Peak	6,152	Ceylon	
Mount Slamat or Tajal . .	11,930	Java	Junghuhn
,, Sumbung	11,030	,,	,,
,, Gounnong Pasama, or Ophir	13,840	Sumatra	Raffles.
Volcano of Matua	4,500	Kurile Is.	Phys. Atlas.
Peak of Unimak	8,593	Aleutian Is.	,,
Mowna Kea	13,953	Sandwich Is.	Wilkes.
,, Roa	13,760	,,	,,

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Tobreonou	12,250	Otaheite	Phys. Atlas.
Mount Wellington, or Kosciusco	6,500	New Holland	Strelizki.
,, Lindsay Lat. 28° 20′ S.	5,700	,,	Mitchell.
,, Canobolas ,, 33 25	4,551	,,	,,
,, Edgecumbe	9,630	New Zealand	Bidwell.
,, Egmont	8,840	,,	Dieffenbach
Tongariro Mountain . . .	6,200	,,	,,
Mount Erebus	12,400	Antartic Lands	Sir J.C. Ross.
,, Terror	10,880		,,

LAKES AND INLAND SEAS.

Sirikol, source of the Oxus .	15,630	Pameo	Wood.
Manasarowar and Raikas Thal	15,250	Tibet	Strachey.
Chumurari Lake	15,000	,,	Cunningham.
Titicaca	12,847	Peru-Bolivia	Pentland.
Baikal	1,535	Asia	A. C.
Lake of Van	566	Turkey in Asia.	,,
Aral	36	Asia	,,
Caspian Sea, *below* the level of the Ocean	82	,,	R. Survey.
Dead Sea, *below* the Ocean .	1,312	Syria	Symond.
Lake Superior	596	N. America	
,, of Lucerne	1,407	Switzerland	Eschman.
,, of Geneva	1,230	,,	,,

HEIGHTS OF SOME REMARKABLE INHABITED PLACES.

Rumihuasi, Post Station . .	15,542	Andes of Peru.	Gaye.
Ayavirini, Post Station . .	14,960	Peru	,,
Pati, Post Station 16° 05′	14,400	,,	Pentland.
Apo ,, ,, 16 13 S.	14,376	,,	,,
Ancochallani, farm 17 35	14,683	,,	,,
Tacora, village . 17 47	13,690	,,	,,
Calamarca . . . 16 54	13,650	Bolivia	,,
Antisana, farm	13,454	Equator	Humboldt.
Potosi, city	13,330	Bolivia	Pentland.

Names of Places, Mountains, &c.	Heights in English Feet.	Countries in which situated.	Authorities.
Puno, city	12,870	Peru	Pentland.
Oruro, ,, ...	12,454	Bolivia	,,
La Paz, ,, ...	12,226	,,	,,
Miquipampa, village . . .	11,870	Peru	Humboldt.
Cusco, city	11,384	,,	Pentland.
Quito, capital of the Equator	9,543	..	Humboldt.
Chuquisaca, capital of Bolivia	9,343	Bolivia	Pentland.
Bogota, capital of New Grenada	8,730	N. Grenada	Humboldt.
Mexico	7,570	Mexico	,,
Arequipa, city	7,852	Peru	Pentland.
Highest villages on S. side of the Himalaya	13,000	Kumäon	Strachey.
Ladak	9,995	Tibet	A. C.
Niti, village	11,473	Kumäon	Webb.
Darjeeling, town	7,165	Sekim Himalaya.	Waugh.
Cabool.	6,382	Afghanistan	Burnes.
Kandahar	5,563	,,	Humboldt.
Teheran	4,137	Persia	A. C.
Kashmir, city	5,818	Kashmir	Hugel.
Hospital of Great St. Bernard	8,110		A. B. L.
,, of St. Gothard . .	6,808	Alps, P.	,,
St. Veran, village.	6,693	,, C.	,,
Breuil, village	6,584	,, P.	P. S.
Barèges, ,, ...	4,072	Pyrenees	A. B. L.
Briançon, town	4,285	Alps, M.	,,
Madrid, city	1,994	Spain	,,
Münich, ,, ...	1,764	Bavaria	,,
Geneva, ,, ...	1,450	Switzerland	,,
Lima, ,, ...	520	Peru	Pentland.
Vienna, ,, ...	436	Austria	A. B. L.
Milan, ,, ...	420	Lombardy	,,
Paris, Observatory	213	France	,,
Rome, Capitol	151	Italy	,,
Berlin	131	Prussia.	,,

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